



Biological Assessment Report

Lindley Creek and Little Lindley Creek Dallas County, Missouri

Fall 2020 - Spring 2021

Prepared for:
Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program
Water Pollution Control Branch

Prepared by:
Missouri Department of Natural Resources
Division of Environmental Quality
Environmental Services Program
Water Quality Monitoring Section

Table of Contents

Section	Page
1.0 Introduction.....	1
2.0 Study Area	2
3.0 Objectives	6
4.0 Methods.....	6
4.1 Land Use Description	7
4.2 Stream Habitat Assessment Project Procedure	7
4.3 Bioassessment	9
4.3.1 Macroinvertebrate Sampling and Analysis	9
4.3.2 Physicochemical Water Sampling and Analysis.....	9
4.3.3 Discharge	10
4.4 Multiparameter Data Logger Deployment.....	10
4.5 Quality Assurance/Quality Control (QA/QC)	10
4.5.1 Field Meters	10
4.5.2 Biological Samples	10
4.5.3 Biological Data Entry	10
4.5.4 Duplicate Sample Collection	11
5.0 Results.....	11
5.1 Land Use	11
5.2 Stream Habitat Assessment.....	12
5.3 Biological Assessment and Macroinvertebrate Community Analysis...	15
5.3.1 Comparison with Wadeable/Perennial Biological Criteria Reference Streams	15
5.3.2 Comparison with Metrics Calculated from Candidate Reference Streams	16
5.3.3 Macroinvertebrate Community Composition and Analysis.....	19
5.4 Physicochemical Water Parameters.....	25
5.5 Data Logger Deployment: Dissolved Oxygen, Temperature, and Conductivity.....	30
5.5.1 Data Logger Deployment, Lindley Creek and Little Lindley Creek.....	31
5.5.2 Data Logger Deployment, CANDREF Stations	36
5.6 Quality Assurance/Quality Control (QA/QC)	40
6.0 Data Trends.....	41
6.1 MSCI Data Comparison.....	41
6.2 Physicochemical Data Comparison	45
7.0 Discussion	48
7.1 Land Use	48
7.2 Stream Habitat Assessment.....	49
7.3 Biological Assessment and Macroinvertebrate Community Analyses...	50
7.4 Physicochemical Water Parameters	51
7.5 Data Logger Deployment.....	52
7.6 Water Quality Sample Duplicate Results	53

7.7	Data Trend	54
8.0	Conclusion	55
9.0	Literature Cited	56

Tables

Table 1	Percent Land Use in the Ozark/Osage EDU, Lindley Creek, Little Lindley Creek, and Candidate Reference Stations	12
Table 2	Lindley Creek, Little Lindley Creek, and Candidate Reference Streams Habitat Values and Scores	13
Table 3	Fall 2020 Metric Values and Scores for Lindley Creek and Little Lindley Creek Using Ozark/Osage Biological Criteria	15
Table 4	Spring 2021 Metric Values and Scores for Lindley Creek and Little Lindley Creek Using Ozark/Osage Biological Criteria	16
Table 5	Fall 2020 Metric Values and Scores for Lindley Creek and Little Lindley Creek Using Candidate Reference Stream Criteria	17
Table 6	Spring 2021 Metric Values and Scores for Lindley Creek and Little Lindley Creek Using Candidate Reference Stream Criteria	18
Table 7	Ozark/Osage BIOREF and CANDREF Metric Threshold Comparison...	19
Table 8	Fall 2020 Macroinvertebrate Community Analysis.....	20
Table 9	Spring 2021 Macroinvertebrate Community Analysis	23
Table 10	Fall 2020 Discharge and <i>In Situ</i> Water Quality Measurements of Lindley Creek and Little Lindley Creek.....	26
Table 11	Fall 2020 Water Chemistry Concentrations of Lindley Creek And Little Lindley Creek.....	26
Table 12	Fall 2020 Discharge and <i>In Situ</i> Water Quality Measurements of Candidate Reference Streams.....	27
Table 13	Fall 2020 Water Chemistry Concentrations of Candidate Reference Streams	28
Table 14	Spring 2021 Discharge and <i>In Situ</i> Water Quality Measurements of Lindley Creek and Little Lindley Creek.....	28
Table 15	Spring 2021 Water Chemistry Concentrations of Lindley Creek	

	and Little Lindley Creek	29
Table 16	Spring 2021 Discharge and <i>In Situ</i> Water Quality Measurements of Candidate Reference Streams	29
Table 17	Spring 2021 Water Chemistry Concentrations of Candidate Reference Streams	30
Table 18	Fall Data Comparison of Little Lindley Creek using BIOREF Biological Criteria.....	42
Table 19	Fall Data Comparison of Little Lindley Creek using CANDREF Biological Criteria.....	43
Table 20	Spring Data Comparison of Little Lindley Creek using BIOREF Biological Criteria.....	43
Table 21	Spring Data Comparison of Little Lindley Creek using CANDREF Biological Criteria.....	44
Table 22	Fall Data Comparison of Discharge and <i>In Situ</i> Water Quality Measurements of Little Lindley Creek	45
Table 23	Fall Data Comparison of Water Chemistry Concentrations of Little Lindley Creek.....	46
Table 24	Spring Data Comparison of Discharge and <i>In Situ</i> Water Quality Measurements of Little Lindley Creek	47
Table 25	Spring Data Comparison of Water Chemistry Concentrations of Little Lindley Creek.....	48

Figures

Figure 1	Lindley Creek and Little Lindley Creek Sampling Locations	4
Figure 2	Location of Test Streams and Candidate Streams in the Ozark/Osage EDU	5

Figure 3	Land Uses within the Lindley Creek and Little Lindley Creek Watersheds	8
Figure 4	Fall 2020 Percent of Taxa by Biotic Index Range	21
Figure 5	Fall 2020 Percent of Taxa by Functional Feeding Group	22
Figure 6	Spring 2021 Percent of Taxa by Biotic Index Range	24
Figure 7	Spring 2021 Percent of Taxa by Functional Feeding Group	25
Figure 8	Lindley Creek 19.5 Multiparameter Data Logger Dissolved Oxygen and Temperature Results. August 11-August 17, 2020	31
Figure 9	Lindley Creek 20.9 Multiparameter Data Logger Dissolved Oxygen and Temperature Results. August 11-August 17, 2020	32
Figure 10	Little Lindley Creek 2.5 Multiparameter Data Logger Dissolved Oxygen and Temperature Results. August 11-August 17, 2020	33
Figure 11	Little Lindley Creek 3.9 Multiparameter Data Logger Dissolved Oxygen and Temperature Results. August 11-August 17, 2020	34
Figure 12	Lindley Creek and Little Lindley Creek Multiparameter Data Logger Conductivity and Temperature Results, August 11-August 17, 2020	35
Figure 13	Brush Creek Multiparameter Data Logger Dissolved Oxygen and Temperature Results. September 3 – September 10, 2020	36
Figure 14	Macks Creek Multiparameter Data Logger Dissolved Oxygen and Temperature Results. September 3-September 10, 2020	37
Figure 15	Saline Creek Multiparameter Data Logger Dissolved Oxygen and Temperature Results. September 3-September 10, 2020	38
Figure 16	Starks Creek Multiparameter Data Logger Dissolved Oxygen and Temperature Results. September 3-September 10, 2020	39
Figure 17	CANDREF Multiparameter Data Logger Conductivity and Temperature Results. September 3-September 10, 2020	40
Figure 18	Fall Metric Score Comparison of Little Lindley Creek	42
Figure 19	Spring Metric Score Comparison of Little Lindley Creek	44

Attachments

- Appendix A Fall and Spring Metric Values and Scores for Candidate Reference Streams using Ozark/Osage Biological Criteria. Separated by Season.
- Appendix B Invertebrate Database Bench Sheet Report Fall 2020 and Spring 2021; Lindley Creek, Little Lindley Creek, Brush Creek, Macks Creek, North Dry Sac River, Saline Creek, and Starks Creek. Grouped by Season and Station.
- Appendix C Multiparameter Data Logger Summary Data; Dissolved Oxygen, Conductivity, and Temperature. Summer 2020.

1.0 Introduction

At the request of the Missouri Department of Natural Resources (**MoDNR**) Water Protection Program (**WPP**), the Environmental Services Program (**ESP**) Water Quality Monitoring Section (**WQMS**) conducted a macroinvertebrate biological assessment and habitat study of Lindley and Little Lindley creeks in Dallas County. WQMS staff collected macroinvertebrate and water quality samples from two Lindley Creek stations and two Little Lindley Creek stations during the fall of 2020 and spring of 2021. Habitat assessments were also conducted during the fall of 2020.

Lindley Creek, a tributary of the Pomme de Terre River, is classified as a class “P” stream with water body identification number (**WBID**) 1436. Lindley Creek is listed in the Missouri Water Quality Standards (**WQS**, MoDNR 2018f) with the following designated uses: irrigation; livestock and wildlife protection; protection of warm water habitat and human health protection; category “B” whole body contact recreation; and secondary contact recreation. Little Lindley Creek, WBID 1438, is classified as a class “C” stream and extends from just downstream of the Buffalo Wastewater Treatment Facility (**WWTF**) outfall to the confluence with Lindley Creek. Little Lindley Creek is listed in the WQS (MoDNR 2018f) with the following designated uses: irrigation; livestock and wildlife protection; protection of warm water habitat and human health protection; category “B” whole body contact recreation; and secondary contact recreation. A class “P” stream is defined as a stream that maintains permanent flow even during drought conditions. A class “C” stream is defined as a stream that may cease flow during drought periods but maintains permanent pools which support aquatic life. Category “B” whole body contact applies to waters that are designated for whole body contact recreation but are not considered public use areas.

Visual surveys conducted between 1992 -1997 by MoDNR on Little Lindley Creek downstream of the Buffalo WWTF found excessive deposits in the form of sludge and algae present on the stream bottom (MoDNR 2007a). It was determined that the facility lacked sufficient holding capacity for sludge, and sludge was being released into the creek during high rain events. Excessive sludge can result in the loss of macroinvertebrate habitat. Studies have also shown high nitrogen and phosphorus levels in Little Lindley Creek downstream of the WWTF. High Biochemical Oxygen Demand (**BOD**) and nutrients were partially attributed to a poultry processor in Buffalo that contributed to the WWTF (MoDNR 2007b).

Little Lindley Creek was placed on the 1998 303(d) list of impaired waters for BOD and Non-Filterable Residue (**NFR**). The Buffalo WWTF was upgraded in 2001, but results from a biological assessment study on Little Lindley Creek at two sampling stations in fall 2002 and spring 2003 indicated the macroinvertebrate community was impaired (MoDNR 2003). The NFR listing was subsequently changed to Volatile Suspended Solids (**VSS**) to better distinguish between organic solids coming from WWTF and mineral solids coming from soil erosion or erosion of mine waste materials or stockpiles.

The sole source of these impairments is listed as the Buffalo WWTF, Permit Number MO-0094854 (MoDNR 2007a).

Although Missouri does not have specific numeric criteria for organic sediment, the following criteria (10 CSR 20-7.031(4) General Criteria) apply:

- (A) Waters shall be free from substances in sufficient amounts to cause the formation of putrescent, unsightly, or harmful bottom deposits or prevent full maintenance of beneficial uses; and
- (C) Waters shall be free from substances in sufficient amounts to cause unsightly color or turbidity, offensive odor, or prevent full maintenance of beneficial uses (MoDNR 2018f).

MoDNR staff observed sludge in the creek during several visits to the WWTF in 2005 and reiterated that the facility does not have adequate sludge holding capacity. In 2007 a Permit in Lieu of a Total Maximum Daily Load was issued (MoDNR 2007a). The permit for the Buffalo WWTF was modified to require the plant to construct improvements for sludge storage that would reduce the amount of sludge released into Little Lindley Creek and to address the poultry processor's discharge into the system. Although the poultry processing facility closed in 2008 (Missourinet 2008), an additional biological assessment in fall 2011 and spring 2012 showed the stream continued to exhibit signs of impairment (MoDNR 2012). This study is a reassessment to examine the health of the macroinvertebrate community and water quality of Little Lindley Creek and Lindley Creek, the receiving stream of Little Lindley Creek.

2.0 Study Area

The test streams were assessed for this study using two sets of biological criteria. Macroinvertebrate samples for all sites were first compared to the Ozark/Osage Ecological Drainage Unit (**EDU**) wadeable/perennial biological criteria reference (**BIOREF**) streams. An EDU is a region in which biological communities and habitat conditions can be expected to be similar. Samples were also compared to candidate reference (**CANDREF**) stream criteria to address potential macroinvertebrate community effects due to stream size.

CANDREF streams were selected based on the small candidate reference stream selection process described in the MoDNR 2018 Listing Methodology Document (MoDNR 2019a). Valley Segment Type (**VST**), five-digit codes developed by the Missouri Resource Assessment Program (**MoRAP**), were used in the selection of CANDREF stream segments (Sowa et al. 2004). CANDREF streams were chosen from a list of streams that had the same or a very similar five-digit VST code as Little Lindley Creek and had little or no observable land uses in their watersheds that may cause water quality problems. CANDREF streams chosen for this study were required to meet the same conditions as BIORREF streams as described in *Biological Criteria for Wadeable/Perennial Streams of Missouri* (MoDNR 2002).

Brush Creek, Macks Creek, North Dry Sac River, and Starks Creek were chosen as CANDREF streams. One BIOREF stream, Saline Creek, had the same VST code as the test streams and was also chosen for comparison. These streams were sampled during the same assessment period as the test streams. Data from the following streams were also used in the CANDREF comparison: Barren Fork, Deer Creek, Dry Fork, and Ingalls Creek. These four streams had been sampled in the past for CANDREF bioassessment purposes. For various reasons (e.g. land use changes, effects of low summer/fall flows) these four streams were not sampled during the current bioassessment. All aforementioned streams and the data generated from them will be referred to as CANDREF throughout the report. Appendix A contains the fall and spring biological metric values and scores for the CANDREF streams using the Ozark/Osage BIOREF criteria.

Station Locations and Descriptions

All Lindley Creek and Little Lindley Creek sampling stations are located within Dallas County (Figure 1). The Little Lindley Creek stations were located downstream of the Buffalo WWTF. The two Lindley Creek stations bracketed the confluence with Little Lindley Creek, with stations located upstream and downstream of the confluence. Station locations and descriptions of Lindley Creek, Little Lindley Creek and the CANDREF streams sampled for this bioassessment are listed below and are shown in Figure 2.

Macroinvertebrate sampling locations of Lindley Creek and Little Lindley Creek

Lindley Creek 19.5 (NE 1/4 S 1/2 sec. 6, T. 34 N., R. 20 W.) is located upstream of Mathis Road. Zone 15 Universal Transverse Mercator (**UTM**) coordinates collected at the downstream boundary of the sample reach are UTME 485421, UTMN 4173318.

Lindley Creek 20.9 (NE 1/4 sec. 7, T. 34 N., R. 20 W.) is located downstream of Highway C. Zone 15 UTM coordinates collected at the upstream boundary of the sample reach are UTME 485703, UTMN 4171741. This station is located upstream of the confluence with Little Lindley Creek and lacks influence from the Buffalo WWTF.

Little Lindley Creek 1.2 (NE 1/4 sec. 8, T. 34 N., R. 20 W.) is located downstream of Highway C. Zone 15 UTM coordinates collected at the upstream boundary of the sample reach are UTME 487366, UTMN 4171319.

Little Lindley Creek 2.5 (NE 1/4 NW 1/4 sec. 16, T. 34 N., R. 20 W.) is located near the end of Fairfield Lane. Zone 15 UTM coordinates collected at the upstream boundary of the sample reach are UTME 488369, UTMN 4169743.

Five streams of similar size to the test streams (one BIOREF stream and four CANDREF streams) were selected within the Ozark/Osage EDU for comparison of biological conditions.

Macroinvertebrate sampling location of the BIOREF station

Saline Creek 2.4 (NE 1/4 sec. 26, T. 41 N., R. 14 W.), Miller County, is located downstream of Saline Road. Zone 15 UTM coordinates of the upstream terminus are UTME 548902, UTMN 4237240.

Figure 1. Lindley Creek and Little Lindley Creek Sampling Locations

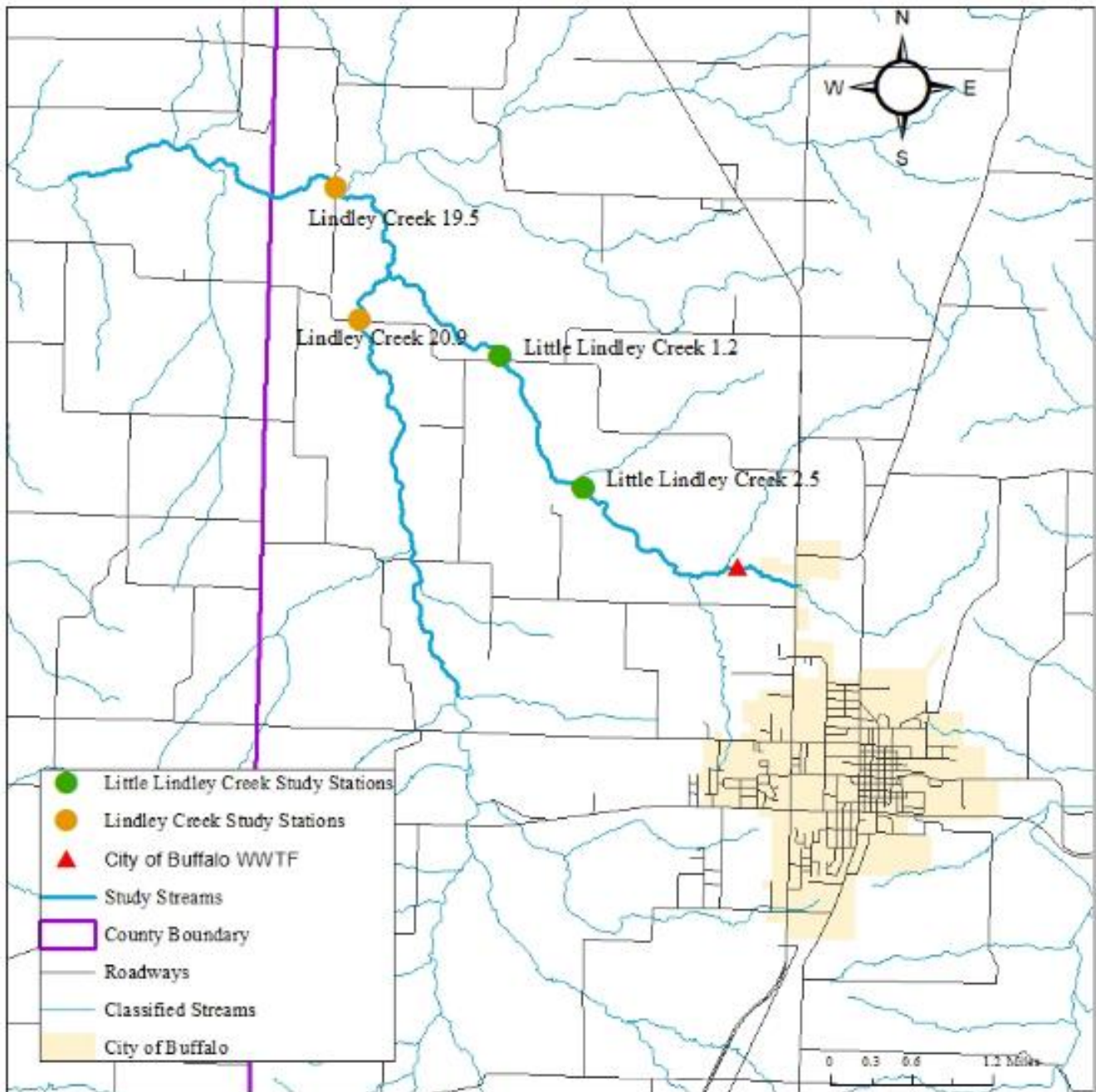
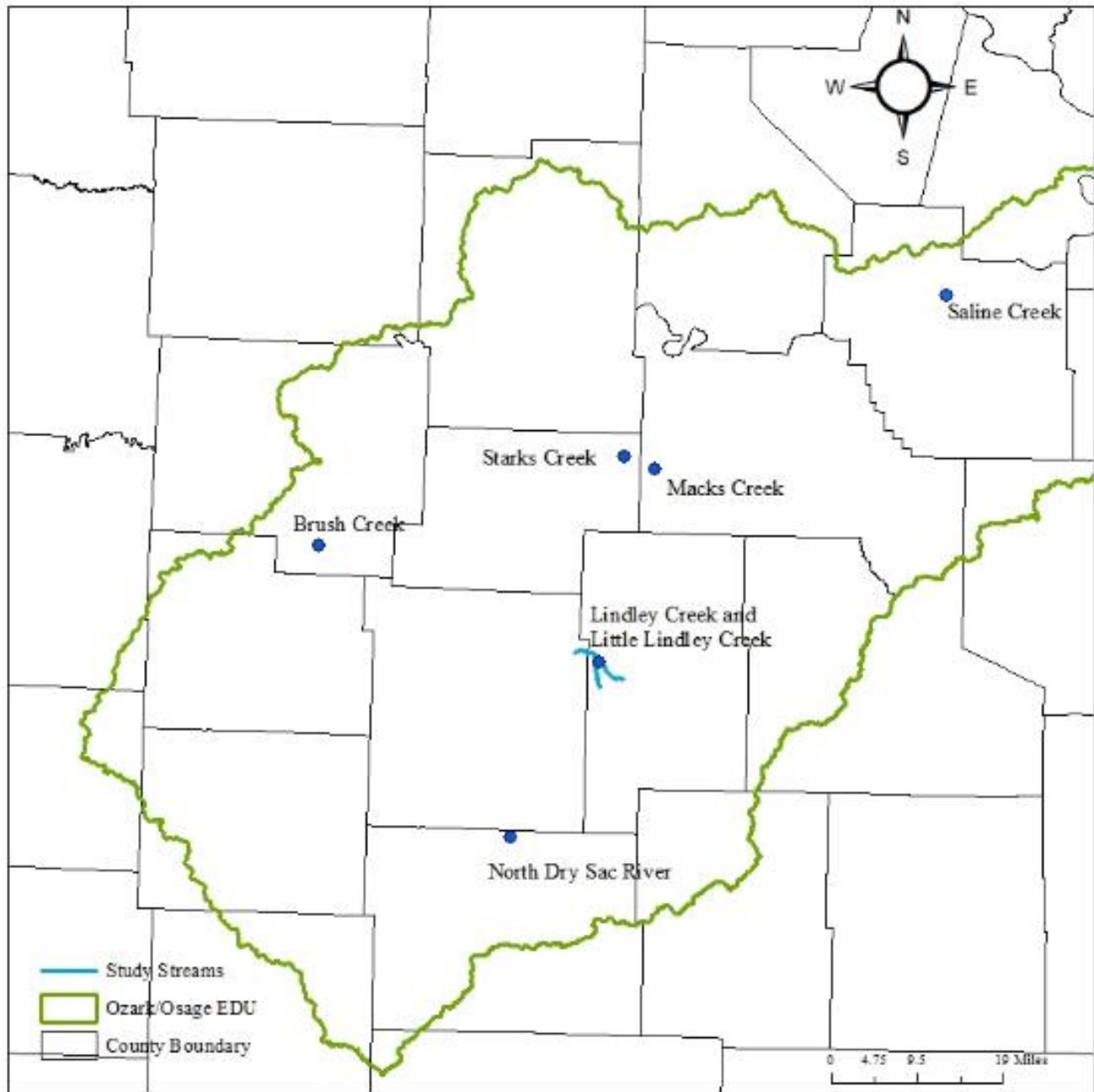


Figure 2. Location of Test Streams and Candidate Streams
in the Ozark/Osage EDU



Macroinvertebrate sampling locations of CANDREF stations

Brush Creek 2.9 (SE 1/4 sec. 8, T. 36 N., R. 25 W.), St. Clair County, is located upstream of Highway J. Zone 15 UTM coordinates of the downstream terminus are UTME 436682, UTMN 4192344.

Macks Creek 2.4 (SE 1/4 sec. 29, T. 38 N., R. 19 W.), Camden County, is located upstream of Coffey Hollow Road. Zone 15 UTM coordinates of the downstream terminus are UTME 496655, UTMN 4206293.

North Dry Sac River 5.2 (NW 1/4 sec. 23, T. 31 N., R. 22 W.), Greene County, is located upstream of County Road 137. Zone 15 UTM coordinates of the downstream terminus are UTME 470911, UTMN 4139877.

Starks Creek 0.6 (SW 1/4 sec. 23, T. 38 N., R. 20 W.), Hickory County, is located downstream of County Road 501. Zone 15 UTM coordinates of the upstream terminus are UTME 491267, UTMN 4208238.

3.0 Objectives

The objective of this study was to determine if Lindley and Little Lindley creeks support the beneficial use designation of supporting aquatic habitat. The macroinvertebrate community was compared longitudinally among the separate sampling stations as well as compared with BIOREF stream data and CANDREF stream data from the Ozark/Osage EDU. Water quality, nutrient parameters, and instream habitat were compared longitudinally among the test sites and with CANDREF data. Water quality parameters were compared with Missouri's WQS (MoDNR 2018f) and EPA's ambient water quality criteria recommendations for nutrients (USEPA 2000).

4.0 Methods

Macroinvertebrate and water quality sampling was conducted during fall 2020 and spring 2021 by WQMS's Aquatic Bioassessment Unit. Fall 2020 sampling of the test stations was conducted on September 22-23. CANDREF streams were sampled September 15-16 with the exception of North Dry Sac River, which was sampled on September 23. Habitat assessments of all sites were conducted September 22-28. The spring 2021 sampling of the test stations was conducted on April 15, and CANDREF stations were sampled March 24-30.

Multiparameter data loggers were deployed during the summer of 2020 to collect continuous dissolved oxygen values. Data loggers were deployed at Lindley Creek and Little Lindley Creek August 11-17 and at CANDREF stations September 3-10. Data logger deployment for this bioassessment was also part of a 48-hour waste allocation (WLA) study of the Buffalo WWTF (MoDNR 2021). The placement of the data loggers on Little Lindley Creek focused on data collection recommendations for the 48-hour WLA study. Loggers were deployed at stations 2.5 and 3.6, located 1.8 and 0.7 miles downstream of the WWTF, respectively. A data logger was not deployed at Little

Lindley Creek station 1.2. During the WLA study, four water chemistry surface water grab samples were collected at all three stations on Little Lindley Creek spanning a 48-hr period. Data loggers were deployed at both sampling stations on Lindley Creek. Data loggers were also deployed at four of the CANDREF streams (Brush, Macks, Saline, Starks creeks). Dry Fork (Polk County) was originally chosen as a CANDREF, but the stream was pooled and not flowing when the data logger was retrieved. As an alternative, North Dry Sac River was chosen for macroinvertebrate sampling, but a data logger was not deployed at this location.

Methods for stream habitat assessments, biological assessments, physicochemical water quality collection, and multiparameter data logger deployment are included in this section. All samples were handled according to the appropriate MoDNR ESP Standard Operating Procedure (**SOP**) or Project Procedure (**PP**).

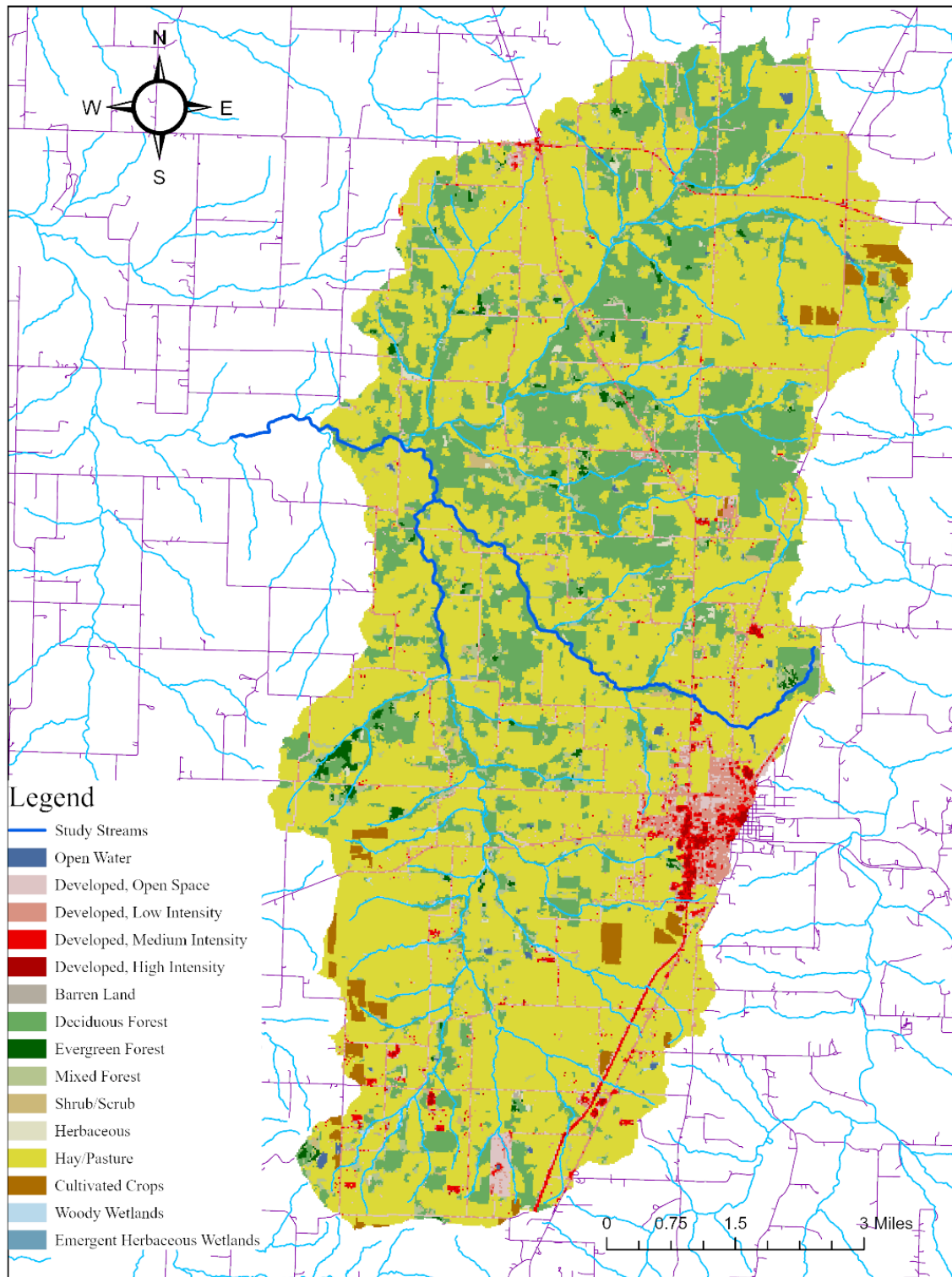
4.1 Land Use Description

Percent land use type and area were calculated using ArcGIS PRO[®] 2.9.7 software by Esri.ArcGIS[®]. Land use type was determined using a 2019 layer from the National Land Cover Database (United States Geological Survey [USGS] 2019). Percent land use type and area were analyzed for each station's estimated catchment-basin and for the EDU as a whole. Figure 3 shows a depiction of the land uses of Lindley Creek and Little Lindley Creek. Table 1 displays the land uses of the EDU, the test stations, and the CANDREF stations.

4.2 Stream Habitat Assessment Project Procedure

Standardized assessment procedures were followed as described for riffle/pool prevalent streams in the Stream Habitat Assessment Project Procedure (**SHAPP**, MoDNR 2019g). According to the SHAPP, an aquatic community is influenced by the quality of the stream habitat. Stream habitat quality is scored for each station, and the scores are compared with a control stream SHAPP score. If the SHAPP score at a test station is ≥ 75 percent of the SHAPP control score, the stream habitat at the test station is considered capable of fully supporting a biological community that is comparable to the control stream. If the test station score is 74 percent to 60 percent of the SHAPP control score, the stream habitat at the test station is considered capable of partially supporting a comparable biological community. If the SHAPP score at a test station is <60 percent of the SHAPP control score, the habitat is considered non-supporting of the biological community.

Figure 3. Land Uses within the Lindley Creek and Little Lindley Creek Watersheds.



4.3 Bioassessment

4.3.1 Macroinvertebrate Sampling and Analysis

Macroinvertebrate sampling was conducted according to the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (**SMSBPP**, MoDNR 2019b). Both Lindley and Little Lindley creeks are considered riffle/pool dominated systems. The three standard habitats sampled at all locations were flowing water over coarse substrate, non-flowing water over depositional substrate, and submerged rootmat. Macroinvertebrate samples were subsampled in the laboratory and identified to taxonomic levels as specified in MoDNR's *Taxonomic Levels for Macroinvertebrate Identifications* SOP (MoDNR 2016c) to develop biological metrics (MoDNR 2019d). Macroinvertebrate bench sheet data are included in Appendix B.

Lindley Creek and Little Lindley Creek macroinvertebrate data were evaluated relative to BIOREF streams in the Ozark/Osage EDU. Biological criteria are calculated separately for the fall (mid-September through mid-October) and spring (mid-March through mid-April) index periods. The SMSBPP provides details on the calculation of metrics and scoring of the multi-metric Macroinvertebrate Stream Condition Index (**MSCI**). The four components of the MSCI are Taxa Richness (**TR**); Ephemeroptera, Plecoptera, and Trichoptera Taxa (**EPTT**); Biotic Index (**BI**); and the Shannon Diversity Index (**SDI**). An MSCI score of 16-20 is considered fully supporting, 10-14 partially supporting, and 4-8 non-supporting of the protection of warm water aquatic habitat beneficial use designation as listed in the Missouri WQS (MoDNR 2018f).

Lindley Creek and Little Lindley Creek samples were also compared to CANDREF streams. This analysis was conducted by calculating biological metric threshold values using CANDREF macroinvertebrate data, which were then used as biological criteria for the same four metrics listed above. This analysis was conducted to determine the extent to which stream size affected the macroinvertebrate community.

4.3.2 Physicochemical Water Sampling and Analysis

Physicochemical water samples were handled according to the appropriate MoDNR ESP SOPs. Results for physicochemical water parameters were examined by season and station by *in situ* field measurements or grab samples collected in accordance with the SOP MDNR-ESP-001, *Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations* (MoDNR 2020b). All samples were kept on ice during transport to ESP.

Water quality parameters were measured *in situ* or collected and returned for analyses at the ESP laboratory in Jefferson City. Turbidity (NTU, MoDNR 2018a) was measured in the ESP, WQMS biology laboratory. Discharge (cubic feet per second-cfs, MoDNR 2020c), DO (mg/L, MoDNR 2019c), conductivity (μ S/cm, MoDNR 2018d), pH (MoDNR 2018b), and temperature ($^{\circ}$ C, MoDNR 2018c), were measured in the field. The ESP Chemical Analysis Section conducted analyses for the following: nitrate plus nitrite-nitrogen, total nitrogen, total phosphorus, ammonia as N, sulfate, chloride, total

suspended solids/non-filterable residue, dissolved calcium, and dissolved magnesium (all parameters reported in mg/L). Physicochemical water parameters were compared among stations as well as with Missouri's WQS (MoDNR 2018f). Nutrient values were compared to U.S. EPA's recommended nutrient values for rivers and streams in nutrient ecoregion XI (USEPA 2000). Interpretation of acceptable limits in the WQS may be dependent on a stream's classification and beneficial uses as designated in the WQS (MoDNR 2018f).

4.3.3 Discharge

Stream flow was measured using a SonTek/YSI FlowTracker® Handheld Acoustic Doppler Velocimeter® at all stations in accordance with the SOP MDNR-ESP-113, *Flow Measurements in Open Channels* (MoDNR 2020c).

4.4 Multiparameter Data Logger Deployment

Data loggers were deployed for a two-week period during anticipated summertime low-flow periods to measure DO, temperature, and conductivity every 15 minutes. YSI Model 600 OMS V2 data loggers (YSI Incorporated, Yellow Springs, Ohio 45387 [a subsidiary of Xylem Incorporated]) were deployed during the summer of 2020 at the test stations as well as the CANDREF stations. Data logger use was conducted following SOP MDNR-ESP-104 *Continuous Monitoring of Water Quality Using a Dissolved Oxygen, Specific Conductivity, pH, Turbidity, Rhodamine Dye, and Temperature Data Logger* (MoDNR 2018e). Tables summarizing the multiparameter data logger data are attached in Appendix C.

4.5 Quality Assurance/Quality Control (QA/QC)

4.5.1 Field Meters

All field meters used to collect water quality parameters were maintained in accordance with *Quality Control Procedures for Checking Water Quality Field Instruments* (MoDNR 2016). Quality control measures for multiparameter data loggers were conducted in accordance with *Continuous Monitoring of Water Quality Using a Dissolved Oxygen, Specific Conductivity, pH, Turbidity, Rhodamine Dye, and Temperature Data Logger* (MoDNR 2018e).

4.5.2 Biological Samples

Steps to assure accuracy of organism removal from sample debris were performed consistent with those methods found in the SMSBPP document (MoDNR 2019b).

4.5.3 Biological Data Entry

All macroinvertebrate data were entered into the WQMS macroinvertebrate database consistent with *Quality Control Procedures for Data Processing* (MoDNR 2019f).

4.5.4 Duplicate Sample Collection

Duplicate samples are obtained from the same location at essentially the same time as the true sample following the same procedures in accordance with *Quality Assurance/Quality Control for Environmental Data Collection* (MoDNR 2019e). True samples and duplicate samples are analyzed for the same set of parameters. A duplicate is used to assess the precision associated with sampling methodology, sample heterogeneity, and analytical procedures (MoDNR 2019e). Duplicate samples for both macroinvertebrates and physicochemical parameters were collected at Little Lindley Creek 2.5 during fall 2020. Duplicate samples are analyzed and reported independently.

5.0 Results

5.1 Land Use

The land use data in Table 1 provide a comparison between the EDU, the test stations and the CANDREF streams. A portion of the Little Lindley Creek watershed is contained within the city limits of Buffalo, resulting in more urban/impervious land use within the stream's watershed. The CANDREF stations have approximately twice as much forested area than the test streams and less hay/pasturelands. The percent of cultivated cropland is higher in the Lindley Creek watershed compared to the CANDREF stations. There was no cultivated cropland in Little Lindley Creek's watershed. Open water and wetlands are comparable among the test stations and the CANDREF stations. Urban/impervious, forested, and hay/pastureland uses are comparable between the EDU and the CANDREF stations. Cultivated cropland and open water is higher in the EDU compared to CANDREFs.

Table 1. Percent Land Use in the Ozark/Osage EDU, Lindley Creek, Little Lindley Creek, and Candidate Reference Stations

Station/ Boundary	Open Water	Urban/ Impervious	Forested	Scrub/ Herbaceous	Hay/ Pasture	Cultivated Crops	Wetlands	Area (miles ²)
Ozark/Osage EDU	3.04	6.37	48.99	1.38	37.36	2.09	0.77	6,785
Lindley Cr. 19.5	0.26	8.19	25.60	0.59	63.75	1.34	0.26	38.9
Lindley Cr. 20.9	0.24	7.79	17.67	0.47	71.13	2.27	0.44	26.6
Little Lindley Cr. 1.2	0.25	15.76	22.35	0.71	60.85	0.0	0.08	10.0
Little Lindley Cr. 2.5	0.30	18.71	19.0	0.73	61.71	0.0	0.09	9.6
Barren Fork	0.10	4.70	53.55	2.12	39.28	0.0	0.24	23.0
Brush Cr.	0.21	5.2	49.45	1.3	42.31	0.99	0.54	80.0
Deer Creek	0.15	3.58	64.43	4.08	26.75	0.01	1.0	58.0
Dry Fork	0.07	4.56	49.78	2.26	43.28	0.00	0.04	28.6
Ingalls Creek	0.09	4.57	47.63	1.84	44.66	0.24	0.98	27.4
Macks Cr.	0.16	5.35	63.53	3.28	27.44	0.0	0.14	31.0
North Dry Sac R.	0.11	6.78	59.29	1.28	32.41	0.04	0.10	26.3
Saline Cr.	0.27	7.37	67.21	0.68	23.79	0.36	0.32	47.0
Starks Cr.	0.15	3.39	55.60	2.21	37.88	0.17	0.60	34.0

5.2 Stream Habitat Assessment

Habitat assessment scoring results are found in Table 2. If the test station SHAPP score is ≥ 75 percent of the control station score, the stations are considered to contain comparable habitats (MoDNR 2019g). Comparable habitats should support similar biological communities. Three of the four test stations scored ≥ 75 percent of the average of CANDREF SHAPP scores. Based on these SHAPP scores, it is inferred that these three stations have habitats similar to the CANDREF streams and should, therefore, support a comparable biological community. Little Lindley Creek 1.2 scored 73 percent average of CANDREF SHAPP scores, indicating this reach of creek is capable of partially supporting a comparable biological community to the CANDREF stations.

Table 2. Lindley Creek, Little Lindley Creek, and Candidate Reference
Streams Habitat Values and Scores

Stream Habitat Parameters	Lindley Cr. 19.5	Lindley Cr. 20.9	Little Lindley Cr. 1.2	Little Lindley Cr. 2.5	Brush Cr. 2.9	Macks Cr. 2.4	North Dry Sac R. 5.2	Saline Cr. 2.4	Starks Cr. 0.6
Habitat Assessment Date 2020	9/22	9/22	9/22	9/23	9/23	9/28	9/23	9/28	9/28
Epifaunal Substrate/Avail. Cover	II(11)	I(16)	II(12)	III(12)	I(16)	II(15)	I(16)	II(11)	II(15)
Embeddedness	II(12)	II(15)	II(13)	I(17)	I(16)	I(16)	I(16)	II(15)	I(16)
Velocity/Depth Regime	III(10)	III(7)	III(7)	II(13)	I(16)	I(16)	II(15)	I(18)	I(17)
Sediment Deposition	II(13)	II(14)	II(12)	II(14)	III(9)	III(9)	II(15)	IV(5)	IV(5)
Channel Flow Status	III(8)	III(8)	II(12)	I(17)	I(18)	I(18)	II(13)	II(14)	I(16)
Channel Alteration	I(20)	I(18)	I(17)	I(18)	I(19)	I(20)	I(18)	I(20)	I(19)
Riffle Quality	III(10)	III(8)	II(12)	II(12)	I(16)	II(15)	I(17)	II(15)	I(18)
Left Bank Stability	III(4)	II(7)	II(8)	I(9)	II(8)	I(9)	I(9)	II(8)	III(5)
Right Bank Stability	I(9)	III(5)	II(8)	I(10)	I(9)	I(10)	II(8)	II(6)	I(10)
Left Bank Vegetative Protection	IV(0)	IV(0)	IV(0)	IV(2)	IV(1)	IV(2)	IV(1)	IV(2)	IV(1)
Right Bank Vegetative Protection	IV(0)	IV(1)	IV(1)	III(3)	IV(1)	III(3)	IV(1)	IV(0)	IV(0)
Left Bank Riparian Zone Width	III(3)	II(8)	IV(1)	III(4)	I(10)	III(4)	I(10)	I(10)	I(9)
Right Bank Riparian Zone Width	II(7)	III(4)	IV(2)	II(5)	I(10)	I(10)	III(4)	I(10)	I(10)
Total Habitat Score	107	111	105	136	149	147	143	134	141
Percent of the average CANDREF Score	75	78	73	95	CANDREF Range 134 -149 Average 143				

Habitat parameter categories range from I to IV with category I = optimal, category II = suboptimal, category III = marginal, and category IV = poor. Habitat parameter scores are listed in parentheses and range from 0 to 20 except for bank stability, vegetative protection, and riparian zone categories, which range from 0 to 10.

Epifaunal substrate in Lindley Creek scored optimal to suboptimal. The downstream station, 19.5, had less epifaunal substrate than station 20.9 upstream due to a higher amount of bedrock exposed in the stream bed. Both stations had a mix of cobble, gravel, and submerged logs with some sediment deposition present. Shallow depth regimes and some areas of deeper water were present, but Lindley Creek stations contained limited areas of “fast” velocity regimes. Embeddedness was suboptimal at both stations, but channel flow status was marginal, only filling approximately half of the channel. Riffles were narrow and short, and riffle quality was marginal at both stations. Bank stability ranged from optimal to marginal, with almost no vegetative protection present. Riparian quality was suboptimal to marginal. Cattle had direct access to the stream at both sampling locations.

Both Little Lindley Creek stations had exposed bedrock in the stream bed. The upstream station, 2.5, contained more extensive areas of exposed bedrock than the downstream station. This abundance of bedrock limited the available areas of cobble, gravel, and instream debris and contributed to the suboptimal epifaunal substrate score. Some sediment deposition was present, but embeddedness was optimal at station 2.5 and suboptimal at station 1.2. Station 1.2 entirely lacked “fast” velocity regimes, and station 2.5 contained limited “fast” velocity regimes. Channel flow status was greater at station 2.5, likely due to proximity to the Buffalo WWTF outfall and constant flow from the discharge. Few channel alterations were present at either station, but cattle had direct access to the stream at both stations. Riffles were wide but not twice as long as the stream width, resulting in a suboptimal ranking. Bank stability ranged from optimal at station 2.5 to suboptimal at station 1.2. Vegetative protection was lower at station 1.2 with less riparian coverage along the banks. Little Lindley Creek station 2.5 scored higher on the habitat assessment than the other three test stations. This station had less embeddedness, and three of the four depth/velocity depth regimes were present as well as higher channel flow status and more stable banks.

The CANDREF stations had a mix of epifaunal substrate. Brush Creek and North Dry Sac River contained larger substrate than Macks, Starks, and Saline creeks. Embeddedness was optimal to suboptimal at all stations. All four velocity depth regimes were present at the CANDREF stations with the exception of North Dry Sac River, which lacked the “fast-deep” depth regime. Sediment deposition was present at all stations, but the greatest instream deposition occurred at Saline and Starks creeks, both of which scored in the “poor” category for this parameter. Channel flow status was optimal to suboptimal, and the stations had few channel alterations. Riffle quality was optimal at three of the stations. Two stations, Macks and Saline creeks had narrower and shorter riffles and ranked high in the suboptimal category. Bank stability varied and scored in the optimal or suboptimal category at most stations with the exception of Starks Creek, which had one bank suffering erosion on one of the outside bends within the sampling reach. Vegetative protection of the banks was low, but the riparian habitat was optimal with a few exceptions that were due to adjacent pasture.

5.3 Biological Assessment and Macroinvertebrate Community Analysis

The SMSBPP metric evaluation used numeric criteria that were calculated from two sources. The first source was ESP’s BIOREF Criteria for Wadeable and Perennial Streams database (Tables 3 and 4) and the second was from the CANDREF streams, which include four candidate reference streams and one BIOREF stream within the Ozark/Osage EDU (Tables 5 and 6). Because Lindley Creek and Little Lindley Creek are smaller than some streams in the biological criteria database, the five CANDREF streams were chosen using the selection process described in the 2019 Listing Methodology Document, part of which requires comparing smaller test streams to similar sized reference quality streams (MoDNR 2019a). These streams were sampled since larger streams may have more habitat and may also have higher macroinvertebrate taxa richness than smaller streams.

5.3.1 Comparison with Wadeable/Perennial Biological Criteria Reference Streams

Tables 3 and 4 provide scoring criteria and results for the fall and spring index periods. MSCI scores were calculated by scoring test station biological metrics using Ozark/Osage BIOREF numeric criteria. An MSCI score of 16-20 is considered fully supporting, 10-14 is partially supporting, and 4-8 is considered non-supporting of the designated beneficial use.

Table 3. Fall 2020 Metric Values and Scores for Lindley Creek and Little Lindley Creek Using Ozark/Osage Biological Criteria

Stations	TR	EPTT	BI	SDI	MSCI	Support
Lindley Cr. 19.5	76 ₍₃₎	15 ₍₃₎	6.2 ₍₅₎	3.36 ₍₅₎	16	F
Lindley Cr. 20.9	80 ₍₃₎	11 ₍₃₎	7.1 ₍₃₎	3.28 ₍₅₎	14	P
Little Lindley Cr. 1.2	66 ₍₃₎	9 ₍₃₎	6.4 ₍₅₎	3.05 ₍₃₎	14	P
Little Lindley Cr. 2.5	58 ₍₃₎	11 ₍₃₎	6.0 ₍₅₎	3.17 ₍₃₎	14	P
Little Lindley Cr. 2.5 duplicate	64 ₍₃₎	10 ₍₃₎	6.3 ₍₅₎	3.09 ₍₃₎	14	P
Metric Score=5	>84	>19	<6.6	>3.23	20-16	Full
Metric Score=3	84-42	19-9	6.6-8.3	3.23-1.61	14-10	Partial
Metric Score=1	<42	<9	>8.3	<1.61	8-4	Non

MSCI Scoring Table (in light gray) developed from BIOREF samples ($n = 28$). TR = Taxa Richness; EPTT = Ephemeroptera, Plecoptera, Trichoptera Taxa; BI = Biotic Index; SDI = Shannon Diversity Index; (#) subscript indicates individual metric scores.

During the fall of 2020, both Little Lindley Creek stations and Lindley Creek 20.9, the upstream station, scored in the partially supporting category when using BIOREF criteria. The downstream station, Lindley Creek 19.5, scored in the fully supporting category. The Little Lindley Creek stations had lower TR values than Lindley Creek. The number of EPT taxa were comparable between the upstream Lindley Creek station and the Little

Lindley Creek stations. Lindley Creek 20.9 had the highest BI value resulting in a score of 3, whereas all other test stations scored 5. Both Lindley Creek stations had higher SDI scores than Little Lindley Creek.

Table 4. Spring 2021 Metric Values and Scores for Lindley Creek and Little Lindley Creek Using Ozark/Osage Biological Criteria

Stations	TR	EPTT	BI	SDI	MSCI	Support
Lindley Cr. 19.5	79 ₍₃₎	13 ₍₃₎	6.9 ₍₃₎	3.02 ₍₃₎	12	P
Lindley Cr. 20.9	69 ₍₃₎	15 ₍₃₎	6.2 ₍₃₎	2.99 ₍₃₎	12	P
Little Lindley Cr. 1.2	50 ₍₃₎	7 ₍₁₎	5.7 ₍₅₎	2.72 ₍₃₎	12	P
Little Lindley Cr. 2.5	53 ₍₃₎	9 ₍₁₎	6.2 ₍₃₎	1.77 ₍₃₎	10	P
Metric Score=5	>90	>22	<6.1	>3.24	20-16	Full
Metric Score=3	90-45	22-11	6.1-8.1	3.24-1.62	14-10	Partial
Metric Score=1	<45	<11	>8.1	<1.62	8-4	Non

MSCI Scoring Table (in light gray) developed from BIOREF samples ($n = 40$). TR = Taxa Richness; EPTT = Ephemeroptera, Plecoptera, Trichoptera Taxa; BI = Biotic Index; SDI = Shannon Diversity Index; (#) subscript indicates individual metric scores.

During spring 2021, all test stations attained partially supporting scores. TR was lowest at the two Little Lindley Creek stations. In addition, these two stations had non-supporting EPTT scores. Little Lindley Creek 1.2 had the lowest BI value and was the only biological metric to attain an optimal score in the spring. SDI scores were suboptimal at all stations. TR and EPTT were higher in Lindley Creek; however, the higher values for TR and EPTT were still suboptimal, suggesting there is likely also a watershed issue at play.

5.3.2 Comparison with Metrics Calculated from Candidate Reference Streams

Tables 5 and 6 provide scoring criteria calculated from CANDREF streams for the fall and spring index periods. MSCI scores were calculated by scoring Lindley Creek and Little Lindley Creek biological metrics using criteria calculated from CANDREF stream samples. An MSCI score of 16-20 is considered fully supporting, 10-14 is partially supporting, and 4-8 is considered non-supporting of the designated use criteria.

Table 5. Fall 2020 Metric Values and Scores for Lindley Creek and Little Lindley Creek using Candidate Reference Stream Criteria

Stations	TR	EPTT	BI	SDI	ΔMSCI	ΔSupport
Lindley Cr. 19.5	76 ₍₃₎	15 ₍₃₎	6.2 _(5→3)	3.36 ₍₅₎	16→14	F→P
Lindley Cr. 20.9	80 ₍₃₎	11 ₍₃₎	7.1 ₍₃₎	3.28 _(5→3)	14→12	P _(NC)
Little Lindley Cr. 1.2	66 ₍₃₎	9 _(3→1)	6.4 _(5→3)	3.05 ₍₃₎	14→10	P _(NC)
Little Lindley Cr. 2.5	58 ₍₃₎	11 ₍₃₎	6.0 ₍₅₎	3.17 ₍₃₎	14 _(NC)	P _(NC)
Little Lindley Cr. 2.5 duplicate	64 ₍₃₎	10 ₍₃₎	6.3 _(5→3)	3.09 ₍₃₎	14→12	P _(NC)
Metric Score=5	>84	>20	<6.1	>3.29	20-16	Full
Metric Score=3	84-42	20-10	6.1-8.1	3.29-1.65	14-10	Partial
Metric Score=1	<42	<10	>8.3	<1.65	8-4	Non

MSCI Scoring Table (in light gray) developed from CANDREF samples ($n = 17$). TR = Taxa Richness; EPTT = Ephemeroptera, Plecoptera, Trichoptera Taxa; BI = Biotic Index; SDI = Shannon Diversity Index; (#) subscript indicates individual metric scores. ΔMSCI shows change from BIOREF score to CANDREF score. ΔSupport shows change in biological support categories. (NC) = no change.

During the fall of 2020, all test stations attained partially supporting MSCI scores. TR was below the fully supporting threshold value at all stations, resulting in partially supporting scores of 3 for this metric. Little Lindley Creek station 1.2 had the lowest EPTT value, resulting in a non-supporting score. Little Lindley Creek station 2.5 had the lowest BI value and was the only station to achieve a fully supporting score for this metric. SDI was highest at the most downstream Lindley Creek station 19.5, attaining a score of 5, but all other stations had partially supporting SDI scores of 3.

Table 6. Spring 2021 Metric Values and Scores for Lindley Creek and Little Lindley Creek using Candidate Reference Stream Criteria

Stations	TR	EPTT	BI	SDI	ΔMSCI	ΔSupport
Lindley Cr. 19.5	79 ₍₃₎	13 ₍₃₎	6.9 ₍₃₎	3.02 ₍₃₎	12 _(NC)	P _(NC)
Lindley Cr. 20.9	69 ₍₃₎	15 ₍₃₎	6.2 ₍₃₎	2.99 ₍₃₎	12 _(NC)	P _(NC)
Little Lindley Cr. 1.2	50 ₍₃₎	7 ₍₁₎	5.7 ₍₅₎	2.72 ₍₃₎	12 _(NC)	P _(NC)
Little Lindley Cr. 2.5	53 ₍₃₎	9 ₍₁₎	6.2 ₍₃₎	1.77 ₍₃₎	10 _(NC)	P _(NC)
Metric Score=5	>89	>27	<6.1	>3.16	20-16	Full
Metric Score=3	89-45	27-13	6.1-8.1	3.16-1.58	14-10	Partial
Metric Score=1	<45	<13	>8.1	<1.58	8-4	Non

MSCI Scoring Table (in light gray) developed from CANDREF samples ($n = 20$). TR = Taxa Richness; EPTT = Ephemeroptera, Plecoptera, Trichoptera Taxa; BI = Biotic Index; SDI = Shannon Diversity Index; (#) subscript indicates individual metric scores. ΔMSCI shows change from BIOREF score to CANDREF score. ΔSupport shows change in biological support categories. (NC) = no change.

All stations scored in the partially supporting category during spring 2021. TR remained suboptimal at all test stations. The two Little Lindley Creek stations had non supporting values for the EPTT metric, BI was lowest at Little Lindley Creek 1.2, and all stations attained partially supporting SDI scores of 3.

Using CANDREF criteria, all stations scored in the partially supporting category during both sampling seasons. During the fall, Little Lindley Creek 2.5 was the only station to attain the same MSCI score using both the BIOREF and CANDREF criteria. In spring, however, all stations maintained the same metric score for the BIOREF and CANDREF comparisons.

There were minor differences between BIOREF and CANDREF biological metric scoring thresholds (Table 7). These differences were evident in the scoring of metrics during the fall. The only change in support category occurred at Lindley Creek station 19.5, the most downstream station, which moved from fully supporting to partially supporting. This change was due to the lower BI metric threshold value of the CANDREF criteria. The BI value for Lindley Creek 19.5 was 0.1 above the CANDREF threshold value, resulting in the score of 14 (the highest partially supporting MSCI score). By comparison, Lindley Creek 19.5 had a score of 16 (the lowest possible fully supporting MSCI score) with the BIOREF data. MSCI scores decreased for all stations except Little Lindley Creek 2.5 during the fall comparison of BIOREF versus CANDREF criteria but not enough to alter the support category. There were no changes in spring data. The only metric to have a notable difference in threshold values in the spring was EPTT, but it was insufficient to alter the metric scores for any of the stations.

Table 7. Ozark/Osage BIOREF and CANDREF Metric Threshold Comparison

	TR	EPTT	BI	SDI	MSCI	Support
Fall Metric Threshold Values						
BIOREF Metric Score=5	>84	>19	<6.6	>3.23	20-16	Full
BIOREF Metric Score=3	84-42	19-9	6.6-8.3	3.23-1.61	14-10	Partial
BIOREF Metric Score=1	<42	<9	>8.3	<1.61	8-4	Non
CANDREF Metric Score=5	>84	>20	<6.1	>3.29	20-16	Full
CANDREF Metric Score=3	84-42	20-10	6.1-8.1	3.29-1.65	14-10	Partial
CANDREF Metric Score=1	<42	<10	>8.3	<1.65	8-4	Non
Spring Metric Threshold Values						
BIOREF Metric Score=5	>90	>22	<6.1	>3.24	20-16	Full
BIOREF Metric Score=3	90-45	22-11	6.1-8.1	3.24-1.62	14-10	Partial
BIOREF Metric Score=1	<45	<11	>8.1	<1.62	8-4	Non
CANDREF Metric Score=5	>89	>27	<6.1	>3.16	20-16	Full
CANDREF Metric Score=3	89-45	27-13	6.1-8.1	3.16-1.58	14-10	Partial
CANDREF Metric Score=1	<45	<13	>8.1	<1.58	8-4	Non

5.3.3 Macroinvertebrate Community Composition and Analysis

Fall Bioassessment Community Composition and Analysis

Table 8 compares the macroinvertebrate community among Lindley Creek and Little Lindley Creek sampling stations for fall 2020. Figure 4 depicts the percent taxa by BI ranges, and Figure 5 depicts the percent of taxa by primary functional feeding group (FFG) for fall.

Table 8. Fall 2020 Macroinvertebrate Community Analysis

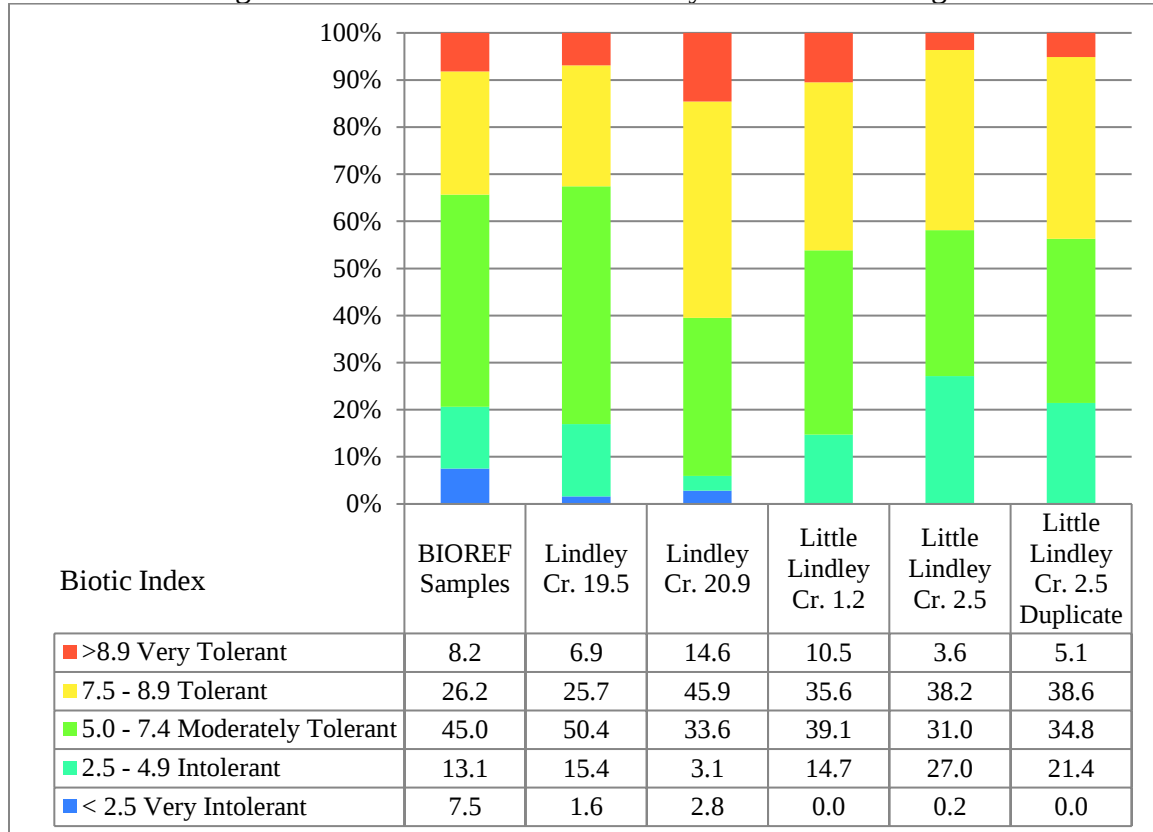
Stations						
Variables	BIOREF Samples	Lindley Cr. 19.5	Lindley Cr. 20.9	Little Lindley Cr. 1.2	Little Lindley Cr. 2.5	Little Lindley Cr. 2.5 duplicate
% Ephemeroptera	34.8	34.5	25.3	14.8	11.7	7.9
% Plecoptera	0.7	2.2	0.3	0.0	0.0	0.0
% Trichoptera	6.8	13.5	0.7	9.7	22.7	25.8
% Total EPT	42.3	50.2	26.3	24.5	34.4	33.7
% Diptera	22.9	19.9	33.8	24.9	14.3	19.2
% Dominant Macroinvertebrate Families						
Chironomidae	21.1	18.3	32.9	24.4	14.1	18.6
Heptageniidae	9.9	12.7	6.7	0.0	2.8	1.9
Baetidae	2.3	12.5	1.0	3.5	4.2	4.4
Hydropsychidae	3.7	11.1	0.0	5.1	10.1	10.4
Caenidae	11.3	7.0	13.7	10.4	4.6	1.7
Coenagrionidae	4.1	5.2	9.4	7.5	5.9	6.1
Psephenidae	1.2	4.7	1.0	5.2	12.4	5.9
Hyalellidae	6.5	4.5	9.3	4.8	10.2	15.0
Planariidae	0.4	1.0	6.5	14.9	6.5	7.7
Philopotamidae	1.0	1.9	0.0	3.5	10.5	13.3
Pleuroceridae	2.4	0.5	0.0	5.8	1.3	0.6
Elmidae	7.9	7.0	6.3	3.2	4.6	4.5

Top 3 families of test stations in bold

The percent of EPT taxa in test stations ranged from 24.5 at Little Lindley Creek 1.2 to 50.2 at Lindley Creek 19.5 in fall 2020 (Table 8). Ephemeroptera were more abundant in Lindley Creek than in Little Lindley Creek. The heptageniid mayfly *Stenonema femoratum* (BI = 7.5) along with caenid mayflies *Caenis anceps* (BI = 7.6) and *C. latipennis* (BI = 7.6) were the most commonly collected mayflies in Lindley Creek. The baetid mayflies *Acerpenna* (BI = 3.7) and *Baetis* (BI = 6.0) were also common in Lindley Creek 19.5. *Caenis latipennis* (BI = 7.6) and *Baetis* (BI = 6.0) were common in Little Lindley Creek stations. *Stenonema femoratum* (BI = 7.5) was collected from Little Lindley Creek 2.5, but it was absent in Little Lindley Creek 1.2. Plecoptera, which were rarely collected in fall BIORREF samples, were present in Lindley Creek; however, they were absent from Little Lindley Creek. The stonefly family Perlidae (specimens were too immature to identify beyond family level) made up 2.2 percent of individuals in the Lindley Creek 19.5 sample. Trichoptera ranged from 0.7 percent at Lindley Creek 20.9 to 25.8 percent at Little Lindley Creek 2.5. The net-spinner *Cheumatopsyche* (BI = 6.6) made up 11.1 percent of the station 19.5 sample but was absent at the upstream Lindley Creek station. *Cheumatopsyche* (BI = 6.6) and the philopotamid *Chimarra* (BI = 2.8) were abundant in both Little Lindley Creek stations.

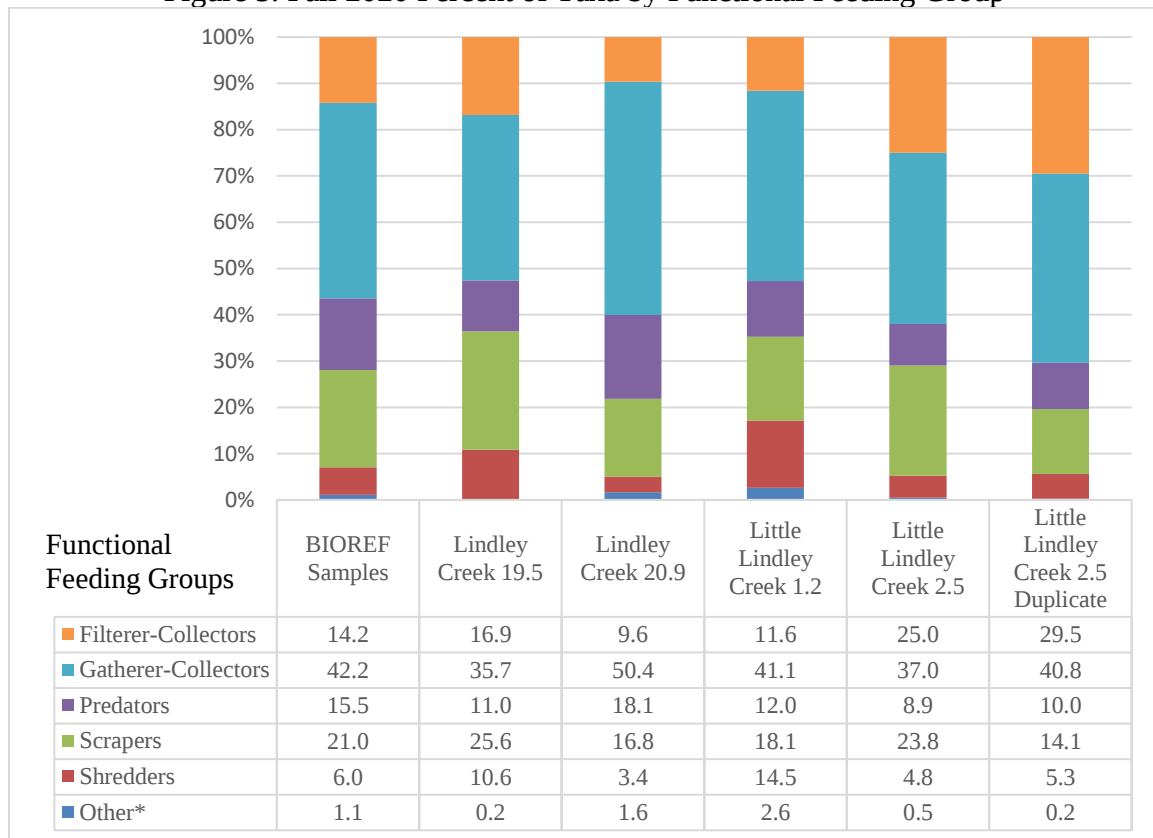
Diptera ranged from 14.3 percent at Little Lindley Creek 2.5 to 33.8 percent at Lindley Creek 20.9 and was made up almost entirely of Chironomidae taxa (non-biting midges) at all stations. At Lindley Creek 20.9, chironomids accounted for almost one-third of the macroinvertebrate community. Some of the more common midge taxa during fall 2020 include *Polypedilum flavum* (BI = 5.3), *Tanytarsus* (BI = 6.7), and *Dicrotendipes* (BI = 7.9).

Figure 4. Fall 2020 Percent of Taxa by Biotic Index Range



For BIOREF samples, taxa in the intolerant BI categories (BI <5.0) made up 20.6 percent of the macroinvertebrate community (Figure 4). Among test stations, the percent of taxa in the intolerant BI categories ranged from 5.9 percent at Lindley Creek 20.9 to 27.2 percent at Little Lindley 2.5. Taxa in the tolerant categories (≥ 5.0 BI) accounted for 79.4 percent of individuals in BIOREF samples. At the test streams, taxa in the tolerant categories ranged from 72.8 percent at Little Lindley 2.5 to 94.1 percent at Lindley Creek 20.9. Specimens in the very intolerant BI category were almost non-existent at the Little Lindley Creek stations.

Figure 5. Fall 2020 Percent of Taxa by Functional Feeding Group



* Other includes parasites, macrophyte piercers, and taxa with no identified FFG

Gatherer-collectors were the most abundant FFG category among BIOREF streams, making up 42.2 percent of fall samples, followed by scrapers at 21.0 percent (Figure 5). Filterer-collectors and predators were similar in abundance. Gatherer-collectors were also the most common FFG category among test stations. Filterer-collectors were most abundant at the farthest upstream Little Lindley Creek station, being almost twice as abundant as they were in Lindley Creek stations. Scrapers and shredders had some variability among test stations.

Spring Bioassessment Community Composition and Analysis

Table 9 compares the macroinvertebrate community among Lindley Creek and Little Lindley Creek sampling stations for spring 2021. Figure 6 depicts the percent taxa by BI ranges and Figure 7 depicts the percent of taxa by primary FFG for spring.

Table 9. Spring 2021 Macroinvertebrate Community Analysis

Stations	BIOREF Samples	Lindley Cr. 19.5	Lindley Cr. 20.9	Little Lindley Cr. 1.2	Little Lindley Cr. 2.5
Variables					
% Ephemeroptera	19.4	11.3	11.4	2.4	1.4
% Plecoptera	7.2	3.0	10.9	0.2	0.1
% Trichoptera	2.6	0.6	0.2	1.5	0.5
% Total EPT	29.2	14.9	22.5	4.2	2.0
% Diptera	51.9	52.6	46.0	60.0	90.6
% Dominant Macroinvertebrate Families					
Chironomidae	47.3	51.1	44.6	58.1	89.8
Crangonyctidae	0.1	12.5	4.9	2.6	1.4
Elmidae	3.3	7.9	9.6	8.4	1.6
Caenidae	7.6	5.0	1.3	0.6	0.4
Baetidae	3.0	4.6	9.5	1.9	1.0
Naididae	2.6	3.6	10.7	1.2	1.0
Perlidae	3.3	2.7	9.0	0.2	0.1
Heptageniidae	4.4	1.7	0.5	0.0	0.0
Planariidae	0.4	1.3	0.7	2.6	1.0
Hyalellidae	4.3	1.0	2.3	0.0	0.0
Pleuroceridae	0.8	0.3	0.2	15.3	0.5

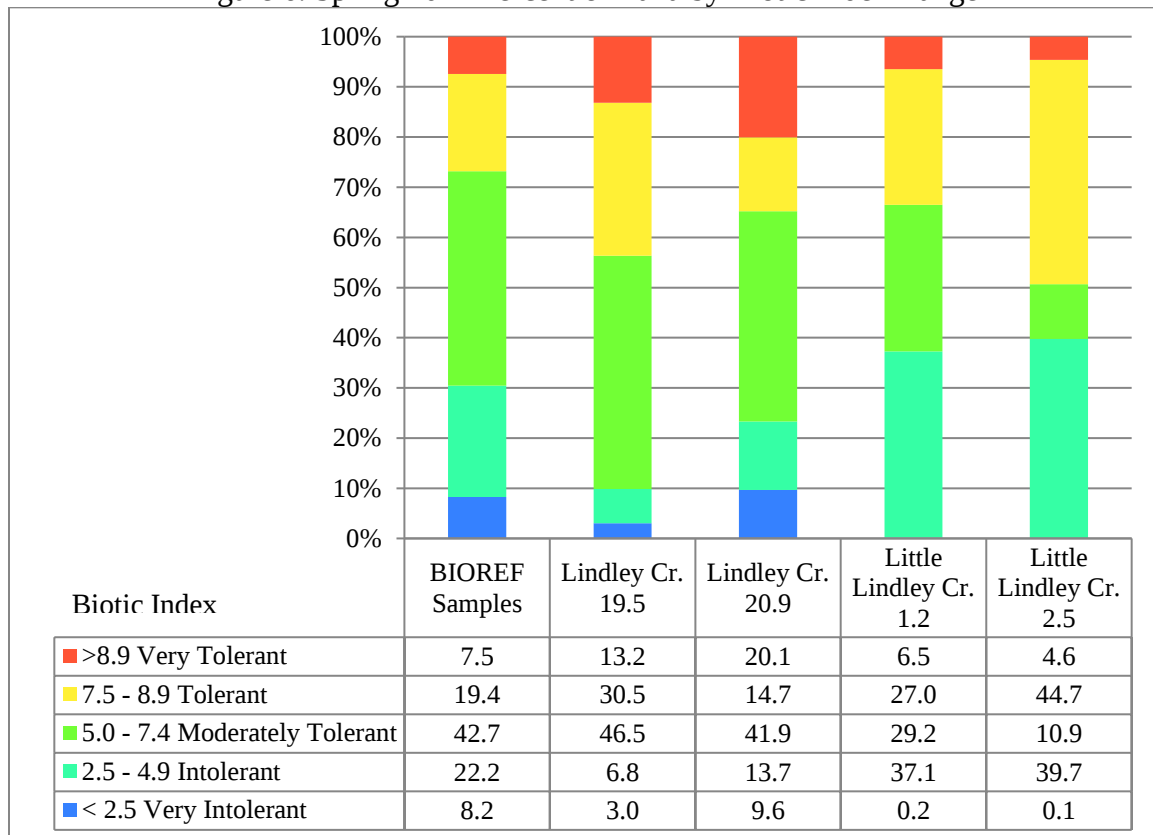
Top 3 families of test stations in bold

In spring 2021, the percentage of EPT taxa ranged from 2.0 at Little Lindley Creek 2.5 to 22.5 at Lindley Creek 20.9 (Table 8). Ephemeroptera and Plecoptera were considerably more abundant at Lindley Creek compared to Little Lindley Creek stations. Trichoptera were most abundant at Little Lindley 1.2. *Caenis latipennis* (BI = 7.6) and *Plautitis* (BI = 6.0) were the most commonly collected mayflies in Lindley Creek. *Caenis latipennis* (BI = 7.6) and *Baetis* (BI = 6.0) were common in Little Lindley Creek stations. The stonefly *Perlesta* (BI = 0) was collected at all test stations and was the only stonefly present in Little Lindley Creek stations. *Amphinemura* (BI = 3.4), *Isoperla* (BI = 2.0), and *Neoperla* (BI = 1.6) were also present in Lindley Creek. Trichoptera ranged from 0.2 percent at Lindley Creek 20.9 to 1.5 percent at Little Lindley Creek 1.2. The Trichoptera *Cheumatopsyche* (BI = 6.6) and *Triaenodes* (BI = 3.7) were collected at all stations. *Oecetis* (BI = 5.7) was present at Lindley Creek stations but absent from Little Lindley Creek stations. *Hydroptila* (BI = 6.2) was absent from Lindley Creek stations but present at Little Lindley Creek stations. The second most common taxon collected at Little Lindley Creek 1.2 was the pleurocerid snail *Elimia* (BI = 2.5), but it was rarely collected at other stations.

Percent Diptera ranged from 44.6 percent at Lindley Creek 20.9 to 89.8 percent at Little Lindley Creek 2.5 and was made up almost entirely of Chironomidae taxa at all stations. The stations closest to the WWTF had the greatest abundance of Diptera taxa. At the Lindley Creek stations, *Stictochironomus* (BI = 6.7) was the most commonly collected

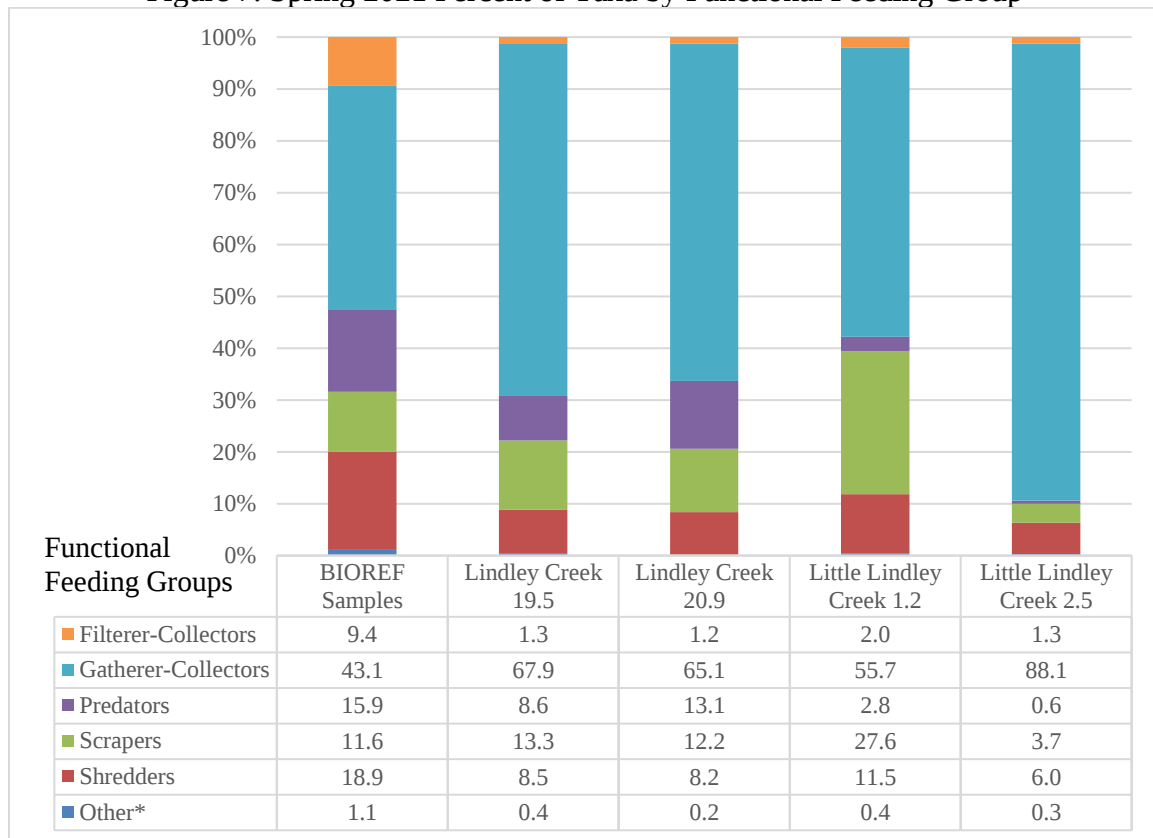
midge. *Eukiefferiella* (BI = 4.0) and *Cricotopus/Orthocladius* (BI = 6.5) were also commonly collected in Lindley Creek. *Dicrotendipes* (BI = 7.9) and *Eukiefferiella* (BI = 4.0) made up the majority of chironomid taxa at both Little Lindley Creek stations. These two taxa accounted for approximately a third of the chironomid taxa at Little Lindley Creek station 1.2 and three fourths of the chironomid taxa at Little Lindley Creek station 2.5. The two taxa were evenly distributed at each station.

Figure 6. Spring 2021 Percent of Taxa by Biotic Index Range



During spring 2021, 30.4 percent of the macroinvertebrate community among BIOREF samples occurred in the intolerant BI categories (<5.0 BI) (Figure 6). Among test stations, percentages in the intolerant BI categories ranged from 9.8 percent at Lindley Creek 19.5 to 39.8 percent Little Lindley Creek 2.5. Taxa in the more tolerant categories (≥ 5.0 BI) made up 69.6 percent of taxa at BIOREF stations. At the test stations, taxa in the more tolerant categories ranged from 90.2 percent at Lindley Creek 19.5 to 60.2 percent at Little Lindley Creek 2.5.

Figure 7. Spring 2021 Percent of Taxa by Functional Feeding Group



* Other includes parasites, macrophyte piercers, and taxa with no identified FFG

Similar to fall samples, gatherer-collectors were the most abundant FFG category among BIOREF streams, making up 43.1 percent of the community (Figure 9). The remaining categories ranged from 1.1 percent “others” to 18.9 percent shredders. Gatherer-collectors made up the majority of test station communities, ranging from 55.7 percent at Little Lindley Creek 1.2 to 88.1 percent at Little Lindley Creek 2.5. Scrapers were the second most common family at three of the four test stations.

5.4 Physicochemical Water Parameters

Discharge and *in situ* water quality results for test stations and CANDREF streams are presented in Tables 10 through 17. Although there are currently no nutrient criteria for Missouri streams and rivers, the nutrient parameters in Lindley Creek, Little Lindley Creek, and the CANDREFs were compared to U.S. EPA’s *Ambient Water Quality Criteria Recommendations for Rivers and Streams in Nutrient Ecoregion XI* (USEPA 2000) for the Ozark Highlands ecoregion. Recommended values for the Ozark Highlands are: 0.24 mg/L nitrate plus nitrite as N, 0.38 mg/L total nitrogen, 0.007 mg/L total phosphorus, and 1.4 NTU turbidity.

Table 10. Fall 2020 Discharge and *In Situ* Water Quality Measurements of Lindley Creek and Little Lindley Creek

Stations	Lindley Cr. 19.5	Lindley Cr. 20.9	Little Lindley Cr. 1.2	Little Lindley Cr. 2.5	Little Lindley Cr. 2.5 duplicate
Parameters					
Sampling date and time	9/22/20; 1010	9/22/20; 1225	9/22/20; 1415	9/23/20; 1105	9/23/20; 1105
Dissolved Oxygen (mg/L)	6.99	7.89	12.71	11.51	11.54
pH (su)	7.92	7.85	8.76	8.49	8.51
Conductivity (µS/cm)	480	418	607	700	699
Temperature (°C)	17.6	18.1	19.6	18.2	18.2
Turbidity (NTU)	3.07	2.36	1.51	1.11	1.39
Discharge (cfs)	0.41	0.03	0.25	0.19	0.15

Values exceeding EPA's recommendations are in bold: 0.24 mg/L NO₂+NO₃-N; 0.38 mg/L TN; 0.007 mg/L TP; 1.4 NTU.

In fall 2020, Little Lindley Creek DO concentrations were higher than the Lindley Creek stations. All stations had DO levels above the WQS criterion of 5.0 mg/L. Conductivity was elevated in Little Lindley Creek compared to Lindley Creek. Little Lindley Creek 2.5 was the only station with turbidity values that did not exceed EPA's recommended values.

Table 11. Fall 2020 Water Chemistry Concentrations of Lindley Creek and Little Lindley Creek

Stations	Lindley Cr. 19.5	Lindley Cr. 20.9	Little Lindley Cr. 1.2	Little Lindley Cr. 2.5	Little Lindley Cr. 2.5 duplicate
Parameters					
Sampling date and time	9/22/20; 1010	9/22/20; 1225	9/22/20; 1415	9/23/20; 1105	9/23/20; 1105
Nitrate+Nitrite as N (mg/L)	1.211	0.106	16.8 ^c	27.1 ^c	25.6 ^c
Total Nitrogen (mg/L)	1.34	0.49	17.2 ^c	28.2 ^c	27.7 ^c
Total Phosphorus (mg/L)	0.12	0.09	0.97	2.47	2.42
Ammonia as N (mg/L)	<0.02 ^a	0.05	<0.2 ^a	0.04 ^b	0.04 ^b
Sulfate (mg/L)	13.1	7.13	20.1	23.0	22.6
Chloride (mg/L)	28.6	9.38	49.5	63.1	62.3
Total Suspended Solids (mg/L)	<5 ^a	<5 ^a	<5 ^a	<5 ^a	<5 ^a

Values exceeding EPA's recommendations are in bold: 0.24 mg/L NO₂+NO₃-N; 0.38 mg/L TN; 0.007 mg/L TP; 1.4 NTU.

^a not detected at reported value;

^b estimated values, detected below PQL;

^c sample diluted during analysis.

Nitrate plus nitrite as N concentrations were elevated at Lindley Creek 19.5, and both Little Lindley Creek samples required dilution during analysis. The Lindley Creek 20.9 nitrate plus nitrite as N concentration was below EPA’s recommendation; it is located upstream of the confluence with Little Lindley Creek and does not have WWTF influence. Total nitrogen was elevated at all stations and required dilution at the Little Lindley Creek stations. Total phosphorus was also elevated at all stations. Sulfate was three times higher at the Little Lindley Creek stations versus Lindley Creek 20.9. Although Little Lindley Creek chloride concentrations were roughly six times higher than Lindley Creek station 20.9, they were well below the aquatic life protection chronic threshold listed in the WQS (MoDNR 2018f).

Table 12. Fall 2020 Discharge and *In Situ* Water Quality Measurements of Candidate Reference Streams

Parameters	Stations	Brush Cr.	Macks Cr.	North Dry Sac R.	Saline Cr.	Starks Cr.
Sampling date and time		9/15/20; 1015	9/15/20; 1454	9/23/20; 0810	9/16/20; 0920	9/15/20; 1303
Dissolved Oxygen (mg/L)		7.80	10.08	7.04	7.51	8.46
pH (su)		8.0	8.3	7.78	8.0	8.0
Conductivity (µS/cm)		425	453	450	406	439
Temperature (°C)		19.0	23.1	17.9	19.8	21.4
Turbidity (NTU)		2.6	0.78	0.52	2.67	7.62
Discharge (cfs)		4.69	5.0	0.22	10.8	3.66

Values exceeding EPA’s recommendations are in bold: 0.24 mg/L NO₂+NO₃-N; 0.38 mg/L TN; 0.007 mg/L TP; 1.4 NTU.

At the CANDREF stations, DO ranged from 7.04 mg/L to 10.08 mg/L in fall 2020. Discharge was lowest at North Dry Sac River, which has the smallest watershed (26.3 square miles) of the CANDREF stations. All stations had DO levels above the WQS minimum criterion of 5.0 mg/L. Turbidity was elevated at Brush, Saline, and Starks creeks when compared to U.S. EPA’s recommended value of 1.4 NTU for the Ozark Highlands ecoregion.

Table 13. Fall 2020 Water Chemistry Concentrations of Candidate Reference Streams

Stations	Brush Cr.	Macks Cr.	North Dry Sac R.	Saline Cr.	Starks Cr.
Parameters					
Sampling date and time	9/15/20; 1015	9/15/20; 1454	9/23/20; 0810	9/16/20; 0920	9/15/20; 1303
Nitrate+Nitrite as N (mg/L)	<0.008 ^a	0.033	0.07	0.324	0.07
Total Nitrogen (mg/L)	0.17	0.08	0.20 ^d	0.41	0.13
Total Phosphorus (mg/L)	0.011	<0.005 ^a	0.014	0.024	0.01
Ammonia as N (mg/L)	<0.02 ^a	<0.02 ^a	<0.02 ^a	<0.02 ^a	<0.02 ^a
Sulfate (mg/L)	14.2	5.46	12.8	9.46	6.43
Chloride (mg/L)	4.82 ^b	2.72 ^b	12.1	6.12	3.27 ^b
Total Suspended Solids (mg/L)	<5 ^a	<5 ^a	<0.5 ^a	<5 ^a	<5 ^a

Values exceeding EPA's recommendations are in bold: 0.24 mg/L NO₂+NO₃-N; 0.38 mg/L TN; 0.007 mg/L TP; 1.4 NTU.

^a not detected at reported value.

^b estimated values, detected below PQL;

^d Estimated Value – Matrix Interference

Among CANDREF stations, Saline Creek nutrient concentrations were highest and were also higher than EPA's recommended nutrient values. Total phosphorus was elevated at Brush Creek, North Dry Sac River, and Starks Creek compared to EPA's recommended value of 0.007 mg/L for the Ozark Highlands ecoregion.

Table 14. Spring 2021 Discharge and *In Situ* Water Quality Measurements of Lindley Creek and Little Lindley Creek

Stations	Lindley Cr. 19.5	Lindley Cr. 20.9	Little Lindley Cr. 1.2	Little Lindley Cr. 2.5
Parameters				
Sampling date and time	4/15/21; 0900	4/15/21; 1035	4/15/21; 1150	4/15/21; 1315
Dissolved Oxygen (mg/L)	9.58	12.06	14.9	16.05
pH (su)	8.2	7.9	7.6	9.01
Conductivity (µS/cm)	357	366	339	344
Temperature (°C)	12.4	12.8	13.7	14.7
Turbidity (NTU)	1.90	2.18	1.88	1.74
Discharge (cfs)	24.2	19.4	6.03	4.57

Values exceeding EPA's recommendations are in bold: 0.24 mg/L NO₂+NO₃-N; 0.38 mg/L TN; 0.007 mg/L TP; 1.4 NTU.

Spring 2021 DO values were again higher in Little Lindley Creek, but conductivity was consistent among all stations. Turbidity was higher than EPA's recommended value of 1.4 NTU at all stations and highest at Lindley Creek 20.9.

Table 15. Spring 2021 Water Chemistry Concentrations
of Lindley Creek and Little Lindley Creek

Stations	Lindley Cr. 19.5	Lindley Cr. 20.9	Little Lindley Cr. 1.2	Little Lindley Cr. 2.5
Parameters				
Sampling date and time	4/15/21; 0900	4/15/21; 1035	4/15/21; 1150	4/15/21; 1315
Nitrate+Nitrite as N (mg/L)	0.683	0.784	1.112	1.717
Total Nitrogen (mg/L)	1.00	0.92	1.32	1.98
Total Phosphorus (mg/L)	0.06	0.071	0.12	0.19
Ammonia as N (mg/L)	0.03 ^b	<0.02 ^a	<0.02 ^a	<0.02 ^a
Sulfate (mg/L)	13.5	11.6	9.71	9.72
Chloride (mg/L)	10.4	8.37	17.5	22.4
Total Suspended Solids (mg/L)	<5 ^a	<5 ^a	<5 ^a	<5 ^a

Values exceeding EPA's recommendations are in bold: 0.24 mg/L NO₂+NO₃-N; 0.38 mg/L TN; 0.007 mg/L TP; 1.4 NTU.

Nitrate plus nitrite as N, total nitrogen, and total phosphorus were above EPA's recommended values at all sampling stations. These nutrient parameters were higher at the Little Lindley Creek sampling stations than Lindley Creek. Unlike the fall samples, none of these parameters required dilution during analysis.

Table 16. Spring 2021 Discharge and *In Situ* Water Quality Measurements
of Candidate Reference Stations

Stations	Brush Cr.	Macks Cr.	North Dry Sac R.	Saline Cr.	Starks Cr.
Parameters					
Sampling date and time	3/30/21; 1010	3/30/21; 1410	3/29/21; 1615	3/24/21; 1315	3/30/21; 1245
Dissolved Oxygen (mg/L)	10.97	10.81	10.83	10.17	11.47
pH (su)	8.04	8.14	8.26	8.05	8.31
Conductivity (µS/cm)	320	343	301	351	337
Temperature (°C)	12.7	14.1	15.9	11.6	13.4
Turbidity (NTU)	2.93	0.62	1.31	3.71	1.10
Discharge (cfs)	69.4	26.6	27.3	80.6	28.8

Values exceeding EPA's recommendations are in bold: 0.24 mg/L NO₂+NO₃-N; 0.38 mg/L TN; 0.007 mg/L TP; 1.4 NTU.

At the CANDREF stations, DO ranged from 10.17 mg/L to 11.47 mg/L. Conductivity was similar at all sampling stations. Turbidity was elevated at Brush and Saline creeks compared to U.S. EPA's recommended value of 1.4 NTU. Discharge was highest at Brush and Saline creeks due to the larger watershed size of these two CANDREF stations.

Table 17. Spring 2021 Water Chemistry Concentrations of Candidate Reference Stations

Stations	Brush Cr.	Macks Cr.	North Dry Sac R.	Saline Cr.	Starks Cr.
Parameters					
Sampling date and time	3/30/21; 1010	3/30/21; 1410	3/29/21; 1615	3/24/21; 1315	3/30/21; 1245
Nitrate+Nitrite as N (mg/L)	0.022	0.091	0.191 ^d	0.318	0.045
Total Nitrogen (mg/L)	0.15	0.03	0.33	0.44	0.12
Total Phosphorus (mg/L)	0.067 ^e	0.05	0.067 ^e	0.05 ^e	0.055 ^e
Ammonia as N (mg/L)	<0.02 ^a	<0.02 ^a	<0.02 ^a	<0.02 ^a	<0.02 ^a
Sulfate (mg/L)	9.85	6.02	10.9	8.64	7.68
Chloride (mg/L)	4.98 ^b	3.43 ^b	8.74	7.10	4.14 ^b
Total Suspended Solids (mg/L)	<5 ^a	<5 ^a	<5 ^a	6.0	<5 ^a

Values exceeding EPA's recommendations are in bold: 0.24 mg/L NO₂+NO₃-N; 0.38 mg/L TN; 0.007 mg/L TP; 1.4 NTU.

^a not detected at reported value;.

^b estimated values, detected below PQL;

^d Estimated Value – Matrix Interference

^e Analyte present in blank at > ½ of reported value.

Nitrate plus nitrite as N was elevated at four of the CANDREF stations. Among CANDREFs total nitrogen was elevated only at Saline Creek, but total phosphorus was elevated at all stations. Chloride and sulfate values were fairly low at all stations. Saline Creek was the only CANDREF station with a detectable total suspended solids concentration.

5.5 Data Logger Deployment: Dissolved Oxygen, Temperature, and Conductivity

Data loggers were deployed at all test and CANDREF stations for one week during the summer of 2020 (Figures 8-17). Dissolved oxygen data for Lindley and Little Lindley creeks are shown in Figures 8 through 11, and conductivity data are shown in Figure 12. Dissolved oxygen for CANDREF stations is shown in Figures 13 through 16, and conductivity data are shown in Figure 17. Data loggers collected DO (mg/L), temperature (°C), and conductivity (µS/cm) measurements every 15 minutes. The QC points for all parameters were within applicable ranges.

Test station data loggers were deployed in the morning of August 11 and retrieved on August 17. CANDREF data loggers were deployed in the morning of September 3 and retrieved September 10. Landowner permission was not granted for sampling access at North Dry Sac River until mid-September, therefore a data logger was not deployed at this station. DO minimums and maximums exhibited daily fluctuations, with peak DO concentrations occurring in the evening before sunset and the minimum DO levels occurring in the early morning after sunrise. Data logger summary tables are in Appendix C. The complete 15-minute interval data set can be made available upon request.

5.5.1 Data Logger Deployment, Lindley Creek, and Little Lindley Creek

Figure 8. Lindley Creek 19.5 Multiparameter Data Logger Dissolved Oxygen and Temperature Results. August 11 – August 17, 2020

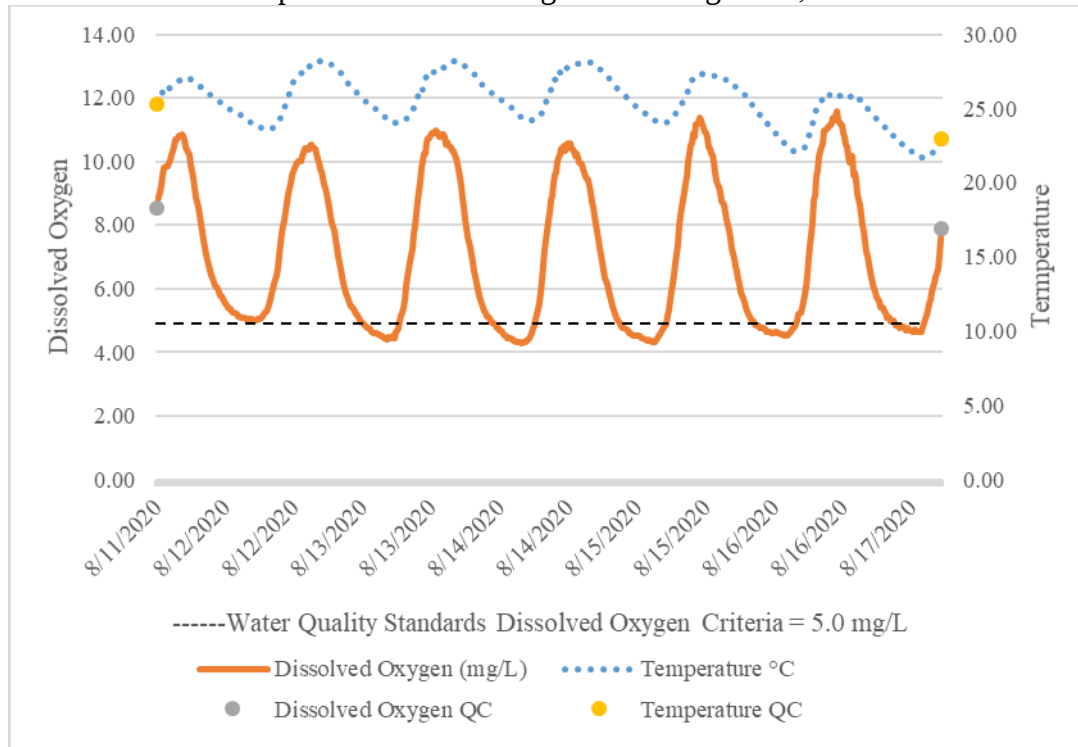


Figure 8 illustrates the DO data for Lindley Creek 19.5, the most downstream station of all test stations. DO ranged from 4.27 mg/L to 11.57 mg/L, and temperature ranged from 21.71 °C to 28.22 °C. During the deployment period, DO at Lindley Creek 19.5 was below the 5.0 mg/L minimum DO criterion specified in the WQS (MoDNR 2018f) 26.9 percent of the time.

Figure 9. Lindley Creek 20.9 Multiparameter Data Logger Dissolved Oxygen and Temperature Results. August 11 – August 17, 2020

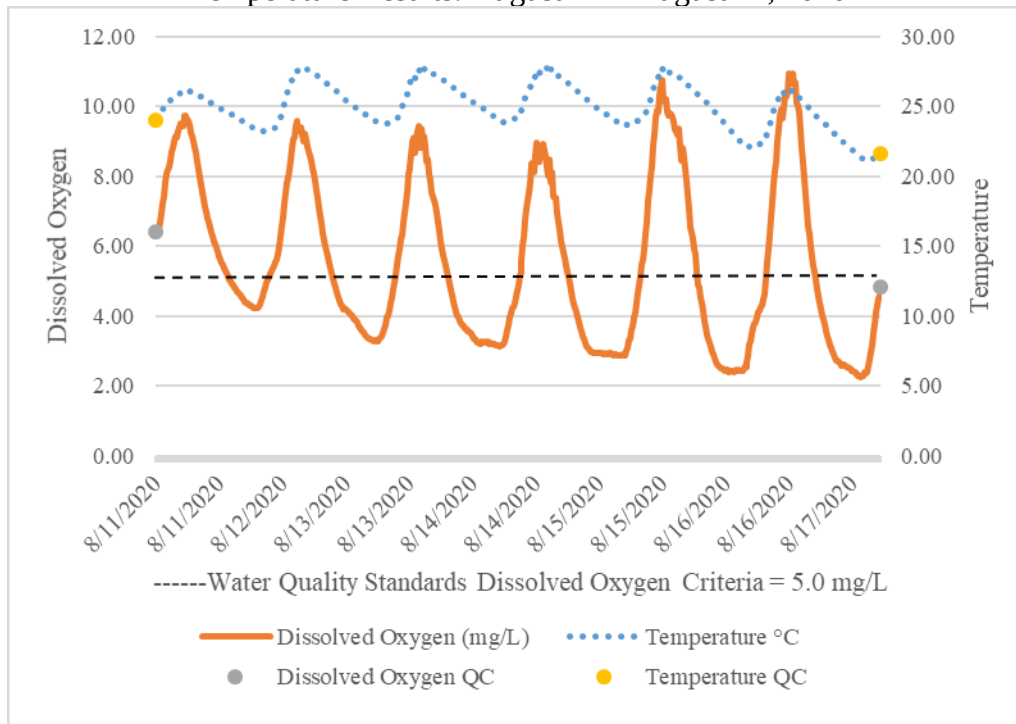


Figure 9 illustrates the DO data for Lindley Creek 20.9, located upstream of the confluence with Little Lindley Creek. DO ranged from 2.26 mg/L to 10.95 mg/L, and temperature ranged from 21.08 °C to 27.92 °C. During the deployment period, DO at Lindley Creek 20.9 was below the 5.0 mg/L minimum WQS DO criterion (MoDNR 2018f) 51.0 percent of the time.

Figure 10. Little Lindley Creek 2.5 Multiparameter Data Logger Dissolved Oxygen and Temperature Results. August 11 – August 17, 2020

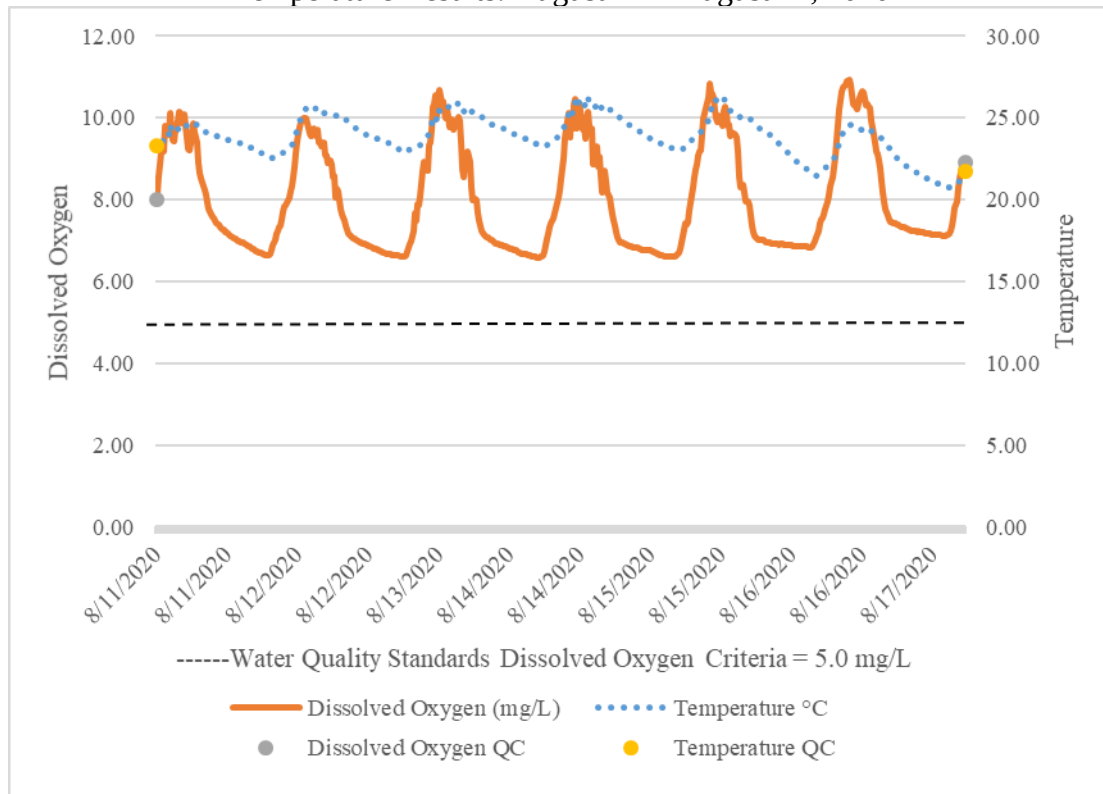


Figure 10 illustrates the DO data for Little Lindley Creek 2.5, located approximately 1.6 miles downstream of the WWTF. DO ranged from 6.59 mg/L to 10.94 mg/L, and temperature ranged from 20.75 °C to 26.20 °C. During the deployment period, DO at Little Lindley Creek 2.5 did not fall below the 5.0 mg/L minimum DO criteria established by the WQS (MoDNR 2018f).

Figure 11. Little Lindley Creek 3.6 Multiparameter Data Logger Dissolved Oxygen and Temperature Results. August 11 – August 17, 2020

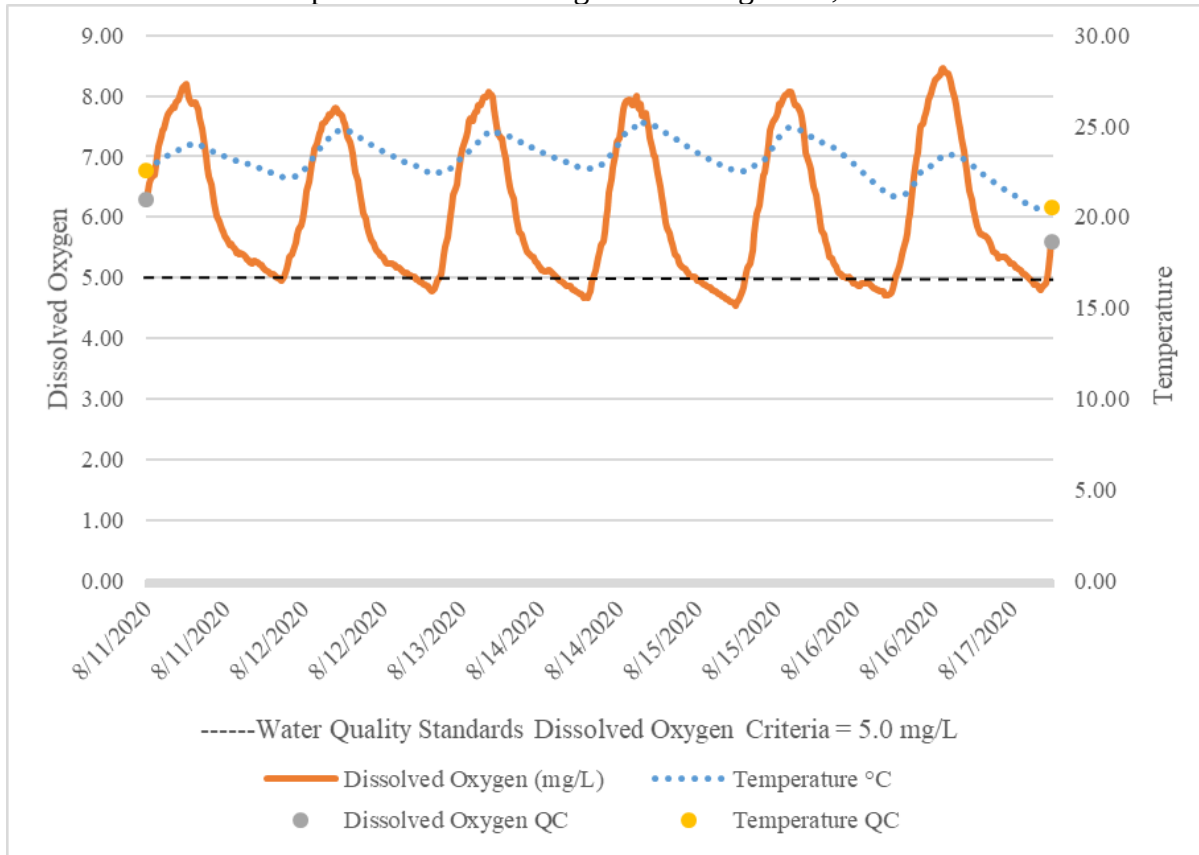


Figure 11 illustrates the DO data for Little Lindley Creek 3.6, located approximately 0.7 miles downstream of the WWTF. DO ranged from 4.53 mg/L to 8.46 mg/L, and temperature ranged from 20.39 °C to 25.22 °C. During the deployment period, DO at Little Lindley Creek 3.6 was below the 5.0 mg/L minimum WQS DO criterion (MoDNR 2018f) 19.4 percent of the time.

Figure 12. Lindley Creek and Little Lindley Creek Multiparameter Data Logger
Conductivity and Temperature Results, August 11 – August 17, 2020

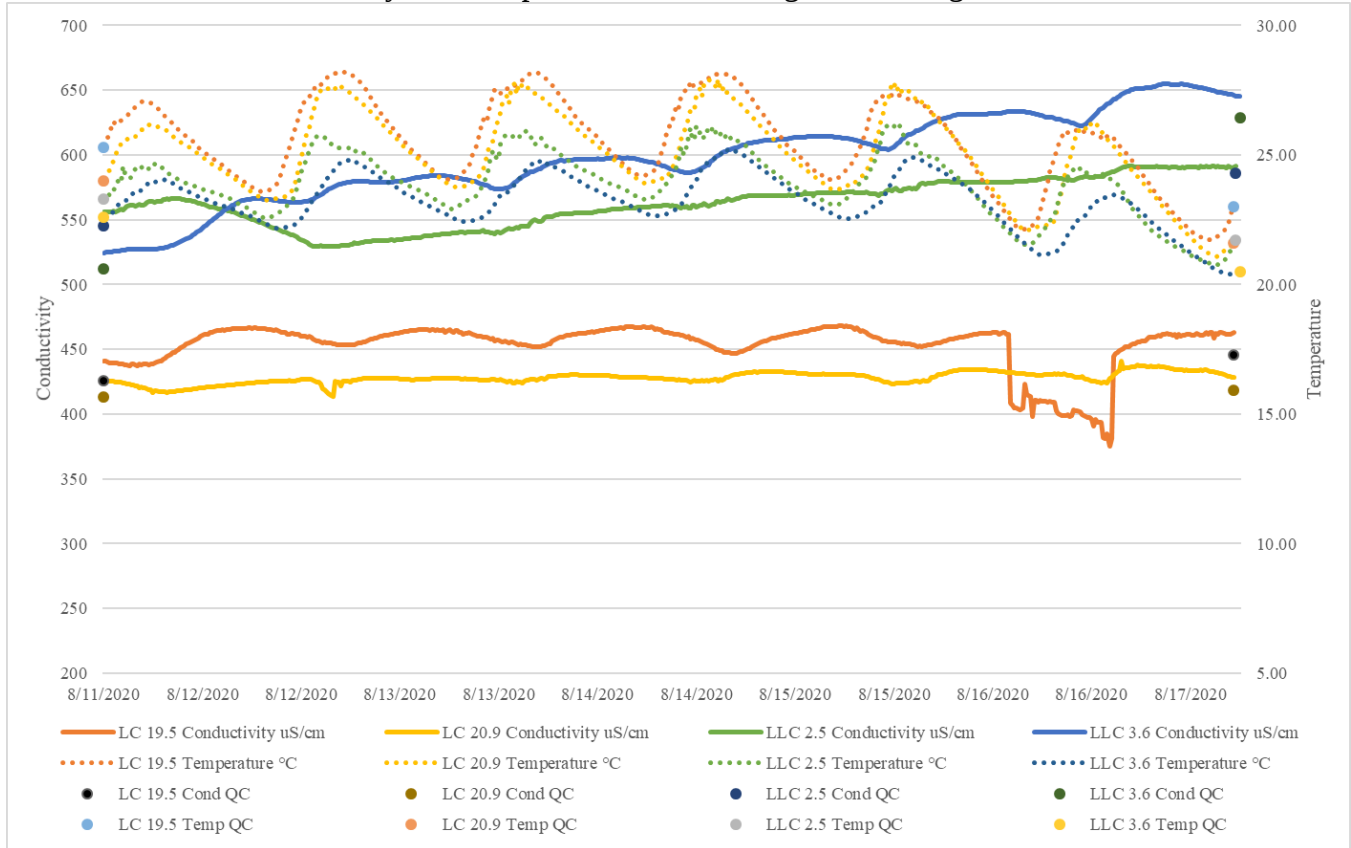


Figure 12 illustrates conductivity at all four test stations during the summer of 2020. At Lindley Creek 19.5 conductivity ranged from 375 $\mu\text{S}/\text{cm}$ to 468 $\mu\text{S}/\text{cm}$, with readings showing an unusual decrease and subsequent rebound occurring on August 16. Conductivity varied little at Lindley Creek 20.9 (from 413 $\mu\text{S}/\text{cm}$ to 441 $\mu\text{S}/\text{cm}$), which is upstream of the Little Lindley Creek confluence. Conductivity values were higher in Little Lindley Creek, likely due to the WWTF influence, ranging from 529 $\mu\text{S}/\text{cm}$ to 655 $\mu\text{S}/\text{cm}$ at Little Lindley Creek 3.6 (the station closest to the WWTF). At Little Lindley Creek 2.5, values ranged from 529 $\mu\text{S}/\text{cm}$ to 595 $\mu\text{S}/\text{cm}$.

Temperature values are also depicted in Figure 12. Temperature was fairly consistent among test stations, ranging from 20.39 °C at Little Lindley 3.9 to 28.22 °C at Lindley Creek 19.5.

5.5.2 Data Logger Deployment, CANDREF Stations

Figure 13. Brush Creek Multiparameter Data Logger Dissolved Oxygen and Temperature Results. September 3 – September 10, 2020

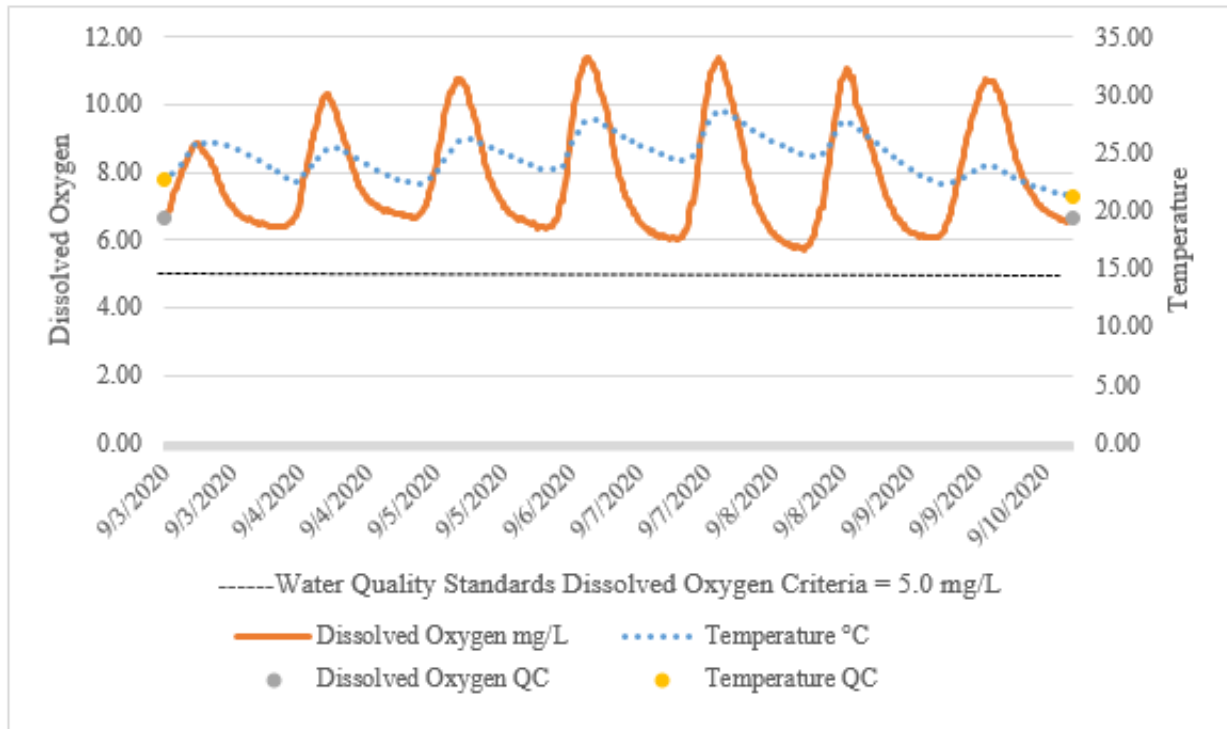


Figure 13 illustrates the DO data for Brush Creek. DO ranged from 5.72 mg/L to 11.41 mg/L, and temperature ranged from 21.24 °C to 28.60 °C. During the deployment period, DO at Brush Creek did not fall below the 5.0 mg/L minimum DO criteria established by the WQS (MoDNR 2018f).

Figure 14. Macks Creek Multiparameter Data Logger Dissolved Oxygen and Temperature Results. September 3 – September 10, 2020

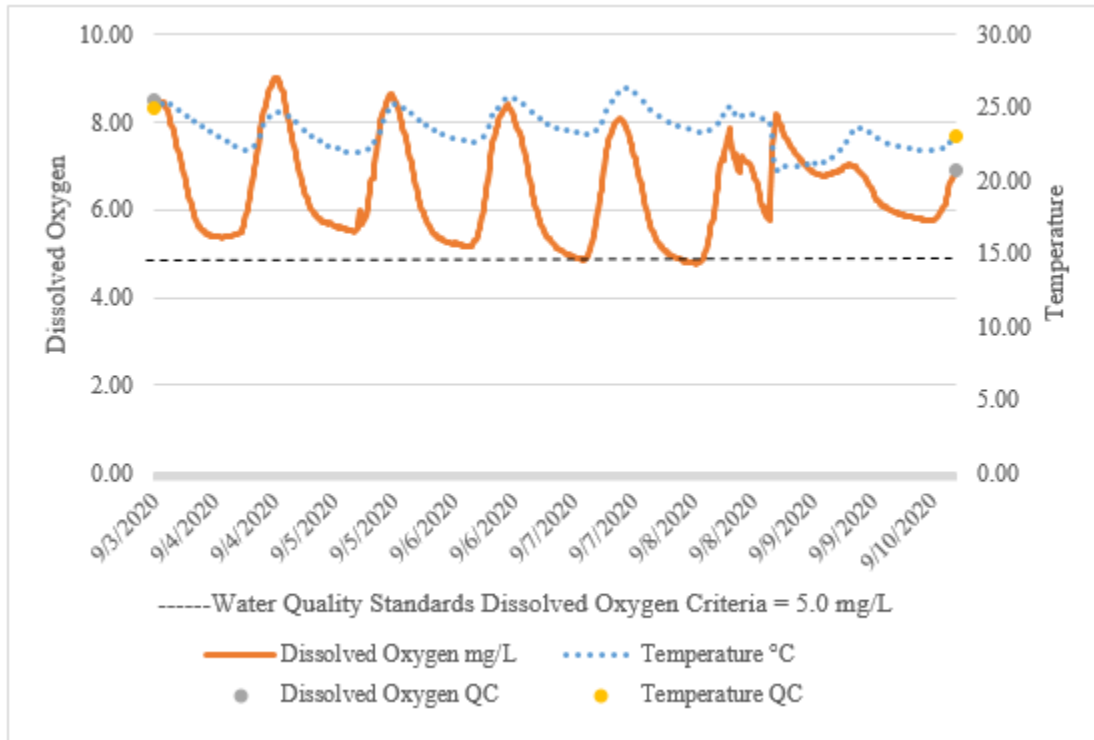


Figure 14 illustrates the DO data for Macks Creek. DO ranged from 4.78 mg/L to 9.01 mg/L, and temperature ranged from 20.72 °C to 26.33 °C. During the deployment period, DO at Macks Creek was below the 5.0 mg/L minimum WQS DO criterion (MoDNR 2018f) 7.2 percent of the time. A localized rain event, approximately 0.7 inches of rain, occurred on September 8 in the Macks Creek and Saline Creek watersheds.

Figure 15. Saline Creek Multiparameter Data Logger Dissolved Oxygen and Temperature Results. September 3 – September 10, 2020

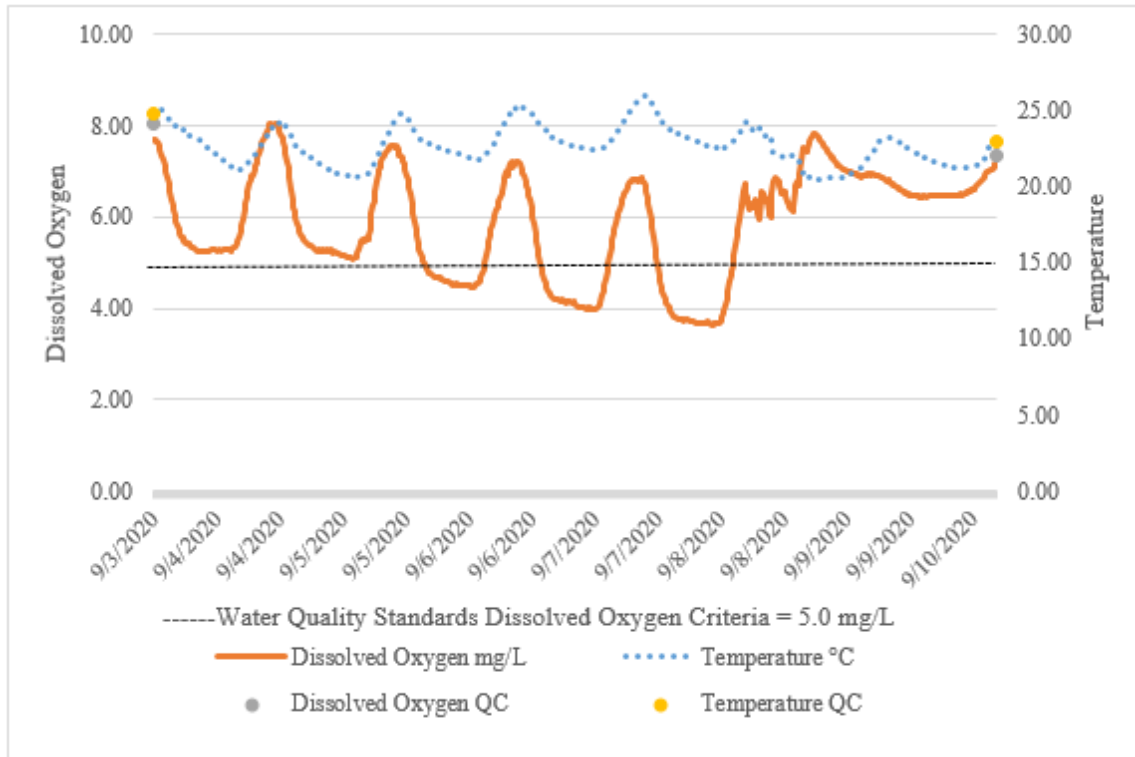


Figure 15 illustrates the DO data for Saline Creek. DO ranged from 3.64 mg/L to 8.06 mg/L, and temperature ranged from 20.42 °C to 25.98 °C. During the deployment period, DO at Saline Creek was below the 5.0 mg/L minimum WQS DO criterion (MoDNR 2018f) 24.5 percent of the time. As mentioned above, a localized rain event occurred on September 8 in the Macks Creek and Saline Creek watersheds.

Figure 16. Starks Creek Multiparameter Data Logger Dissolved Oxygen and Temperature Results. September 3 – September 10, 2020

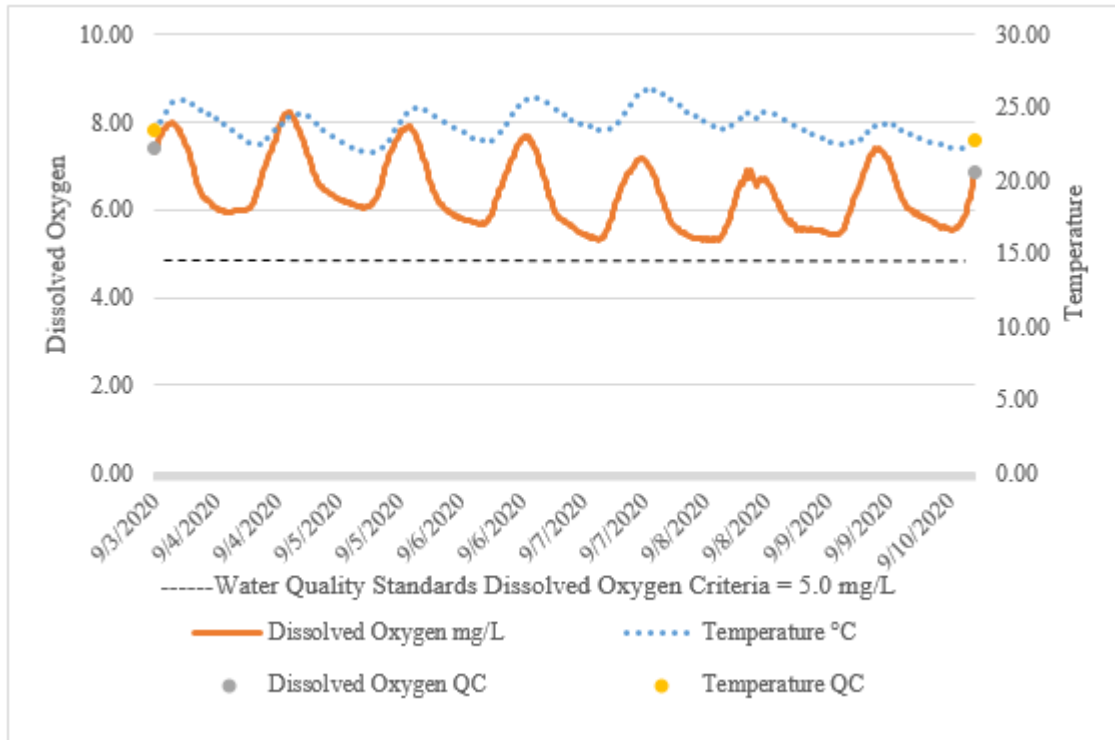


Figure 16 illustrates the DO data for Starks Creek. DO ranged from 5.32 mg/L to 8.21 mg/L, and temperature ranged from 21.89 °C to 26.29 °C. During the deployment period, DO at Starks Creek did not fall below the 5.0 mg/L minimum DO criteria established by the WQS (MoDNR 2018f).

Figure 17. CANDREF Multiparameter Data Logger Conductivity and Temperature Results, September 3 – September 10, 2020

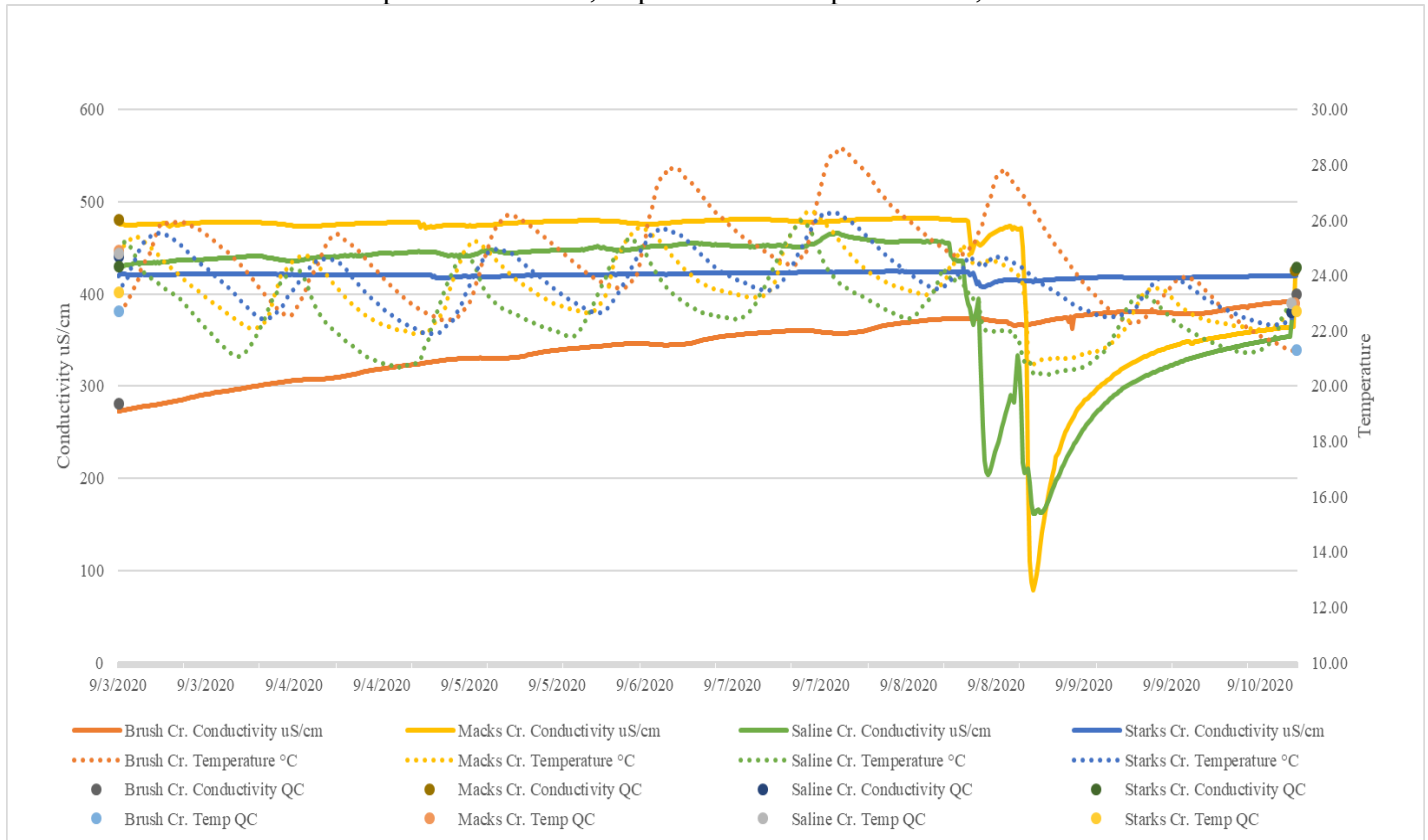


Figure 12 illustrates conductivity at all four CANDREF stations during the summer of 2020. Conductivity was stable except following a localized rain on September 8 in the Macks and Saline creek watersheds. At Macks Creek, conductivity dropped to 79 $\mu\text{S}/\text{cm}$, and Saline Creek dropped to 162 $\mu\text{S}/\text{cm}$. Conductivity ranged from 273 $\mu\text{S}/\text{cm}$ at Brush Creek to 424 $\mu\text{S}/\text{cm}$ at Starks Creek. Temperature values are also depicted in Figure 12. Temperature ranged from 20.42 $^{\circ}\text{C}$ at Saline Creek to 28.60 $^{\circ}\text{C}$ at Brush Creek.

5.6 Quality Assurance/Quality Control (QA/QC)

Quantitative Similarity Index for Taxa (QSIT) can be used as a quality control measure that expresses taxa similarity between two samples as a percentage. QSIT was calculated for the duplicate macroinvertebrate samples collected at Little Lindley Creek 2.5 during the fall of 2020. Duplicate samples are expected to have a score of 70 percent or greater (Rabeni et al. 1999). During the fall 2020, the QSIT at Little Lindley Creek was 82.1 percent.

The duplicate sample difference criteria for the physicochemical parameters are specified in the Fiscal Year 2021 Quality Assurance Project Plan (MoDNR 2020a). A duplicate sample was collected for physicochemical parameters at Little Lindley Creek 2.5 during

the fall 2020. Discharge and turbidity both exceeded the duplicate difference criteria of 20 percent. Discharge values of 0.15 cfs and 0.19 cfs and turbidity values of 1.39 NTU and 1.11 NTU were recorded for the two samples.

Quality control measures were performed on the multiparameter data loggers prior to deployment and when the loggers were retrieved. Quality control procedures are described in SOP MDNR-ESP-104 *Continuous Monitoring of Water Quality Using a Dissolved Oxygen, Specific Conductivity, pH, Turbidity, Rhodamine Dye, and Temperature Data Logger* (MoDNR 2018e). Data loggers collected DO, temperature, and conductivity. All parameters were within the specified ranges.

6.0 Data Trends

Little Lindley Creek has been the subject of two past bioassessment studies: fall 2002-spring 2003 and fall 2011- spring 2012. Attempts were made to replicate sampling stations, but due to lack of landowner permission, sites differed slightly between studies. Despite differences in sampling locations, two stations were chosen during each bioassessment period. Lindley Creek was not included in either of the past bioassessments, but two stations bracketing the Little Lindley Creek confluence were chosen for this current bioassessment. A comparison of bioassessment scores using BIOREF data during the fall sampling events is shown in Table 18 and depicted in Figure 18. The comparison of bioassessment scores using CANDREF data during the fall sampling events is shown in Table 19. Spring BIOREF data are shown in Table 20 and depicted in Figure 19. The comparison of bioassessment scores using CANDREF data during the spring sampling events is shown in Table 21.

6.1 MSCI Data Comparison

During fall 2002, both sampling stations attained partially supporting MSCI scores. The upstream station scored lower due to fewer EPT taxa. In fall 2011, both stations were fully supporting with a higher taxa richness, lower BI, and higher SDI. During the most recent sampling event, fall 2020, the stations maintained the lower BI (compared to 2002 data), but TR and SDI were lower (compared to 2011), resulting in both stations having partially supporting MSCI scores.

Table 18. Fall Data Comparison of Little Lindley Creek
Using BIOREF Biological Criteria

Stations	TR	EPTT	BI	SDI	MSCI	Support
2002						
Little Lindley Cr. 1.2	66 ₍₃₎	12 ₍₃₎	6.9 ₍₃₎	2.49 ₍₃₎	12	P
Little Lindley Cr. 3.0	48 ₍₃₎	6 ₍₁₎	6.9 ₍₃₎	2.82 ₍₃₎	10	P
2011						
Little Lindley Cr. 0.9	79 ₍₃₎	12 ₍₃₎	5.9 ₍₅₎	3.34 ₍₅₎	16	F
Little Lindley Cr. 2.5	70 ₍₃₎	12 ₍₃₎	6.4 ₍₅₎	3.46 ₍₅₎	16	F
2020						
Little Lindley Cr. 1.2	66 ₍₃₎	9 ₍₃₎	6.4 ₍₅₎	3.05 ₍₃₎	14	P
Little Lindley Cr. 2.5	58 ₍₃₎	11 ₍₃₎	6.0 ₍₅₎	3.17 ₍₃₎	14	P
Little Lindley Cr. 2.5 duplicate	64 ₍₃₎	10 ₍₃₎	6.3 ₍₅₎	3.09 ₍₃₎	14	P

MSCI Scoring Table (in light gray) developed from BIOREF samples ($n = 28$). TR = Taxa Richness; EPTT = Ephemeroptera, Plecoptera, Trichoptera Taxa; BI = Biotic Index; SDI = Shannon Diversity Index; (#) subscript indicates individual metric scores.

Figure 18. Fall Metric Score Comparison of Little Lindley Creek

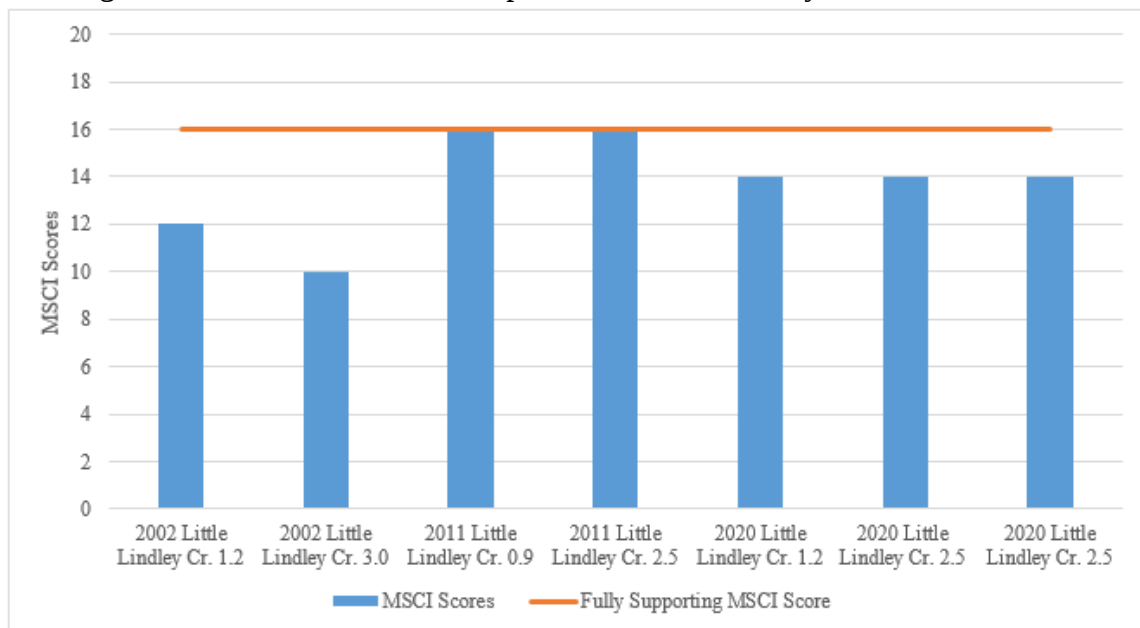


Table 19. Fall Data Comparison of Little Lindley Creek
Using CANDREF Biological Criteria

Stations	TR	EPTT	BI	SDI	MSCI	Support
2002						
Little Lindley Cr. 1.2	66 ₍₃₎	12 ₍₃₎	6.9 ₍₃₎	2.49 ₍₃₎	12	P_(NC)
Little Lindley Cr. 3.0	48 ₍₃₎	6 ₍₁₎	6.9 ₍₃₎	2.82 ₍₃₎	10	P_(NC)
2011						
Little Lindley Cr. 0.9	79 _(3→5)	12 ₍₃₎	5.9 ₍₅₎	3.34 ₍₅₎	16→18	F_(NC)
Little Lindley Cr. 2.5	70 ₍₃₎	12 ₍₃₎	6.4 _(5→3)	3.46 ₍₅₎	16→14	F→P
2020						
Little Lindley Cr. 1.2	66 ₍₃₎	9 _(3→1)	6.4 _(5→3)	3.05 ₍₃₎	14→10	P_(NC)
Little Lindley Cr. 2.5	58 ₍₃₎	11 ₍₃₎	6.0 ₍₅₎	3.17 ₍₃₎	14 _(NC)	P_(NC)
Little Lindley Cr. 2.5 duplicate	64 ₍₃₎	10 ₍₃₎	6.3 _(5→3)	3.09 ₍₃₎	14→12	P_(NC)

TR = Taxa Richness; EPTT = Ephemeroptera, Plecoptera, Trichoptera Taxa; BI = Biotic Index; SDI = Shannon Diversity Index; (#) subscript indicates individual metric scores.

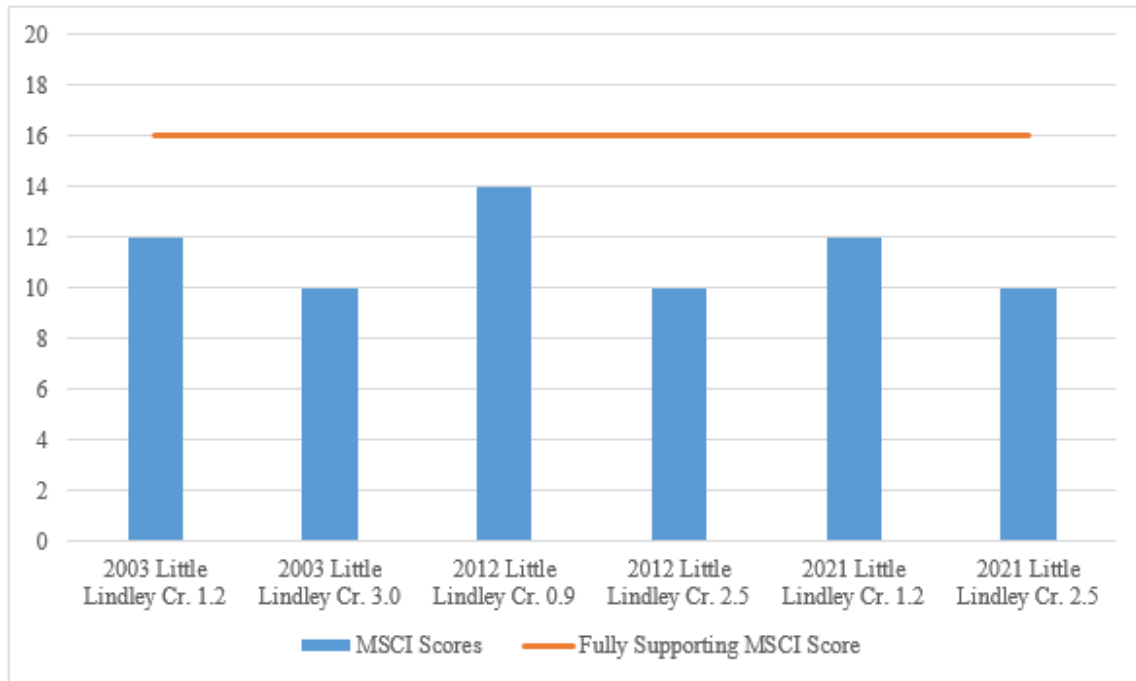
When using CANDREF data in the comparison, Little Lindley Creek station 2.5 changed from fully supporting of the beneficial use criteria to partially supporting due to a lower BI score in the fall of 2011. This was the only station to change support categories.

Table 20. Spring Data comparison of
Little Lindley Creek Using BIOREF Biological Criteria

Stations	TR	EPTT	BI	SDI	MSCI	Support
2003						
Little Lindley Cr. 1.2	70 ₍₃₎	16 ₍₃₎	7.6 ₍₃₎	2.97 ₍₃₎	12	P
Little Lindley Cr. 3.0	51 ₍₃₎	9 ₍₁₎	7.0 ₍₃₎	2.91 ₍₃₎	10	P
2012						
Little Lindley Cr. 0.9	79 ₍₃₎	12 ₍₃₎	5.5 ₍₅₎	3.07 ₍₃₎	14	P
Little Lindley Cr. 2.5	63 ₍₃₎	8 ₍₁₎	6.5 ₍₃₎	2.71 ₍₃₎	10	P
2021						
Little Lindley Cr. 1.2	50 ₍₃₎	7 ₍₁₎	5.7 ₍₅₎	2.72 ₍₃₎	12	P
Little Lindley Cr. 2.5	53 ₍₃₎	9 ₍₁₎	6.2 ₍₃₎	1.77 ₍₃₎	10	P

MSCI Scoring Table (in light gray) developed from BIOREF samples ($n = 40$). TR = Taxa Richness; EPTT = Ephemeroptera, Plecoptera, Trichoptera Taxa; BI = Biotic Index; SDI = Shannon Diversity Index; (#) subscript indicates individual metric scores.

Figure 19. Spring Metric Score Comparison of Little Lindley Creek



All stations consistently attained partially supporting MSCI scores during the three separate spring sampling events. In spring 2003, the two stations were similar to fall, reaching MSCI scores of 12 and 10, with the upstream station having few EPT. During 2012, BI was lower than the corresponding fall sampling, but not enough to increase the support category to fully supporting. During 2021, TR decreased and both stations had non-supporting individual metric scores for EPTT.

Table 21. Spring Data comparison of
Little Lindley Creek Using CANDREF Biological Criteria

Stations	TR	EPTT	BI	SDI	MSCI	Support
2003						
Little Lindley Cr. 1.2	70 ₍₃₎	16 ₍₃₎	7.6 ₍₃₎	2.97 ₍₃₎	12	P_(NC)
Little Lindley Cr. 3.0	51 ₍₃₎	9 ₍₁₎	7.0 ₍₃₎	2.91 ₍₃₎	10	P_(NC)
2012						
Little Lindley Cr. 0.9	79 ₍₃₎	12 _(1→3)	5.5 ₍₅₎	3.07 ₍₃₎	12→14	P_(NC)
Little Lindley Cr. 2.5	63 ₍₃₎	8 ₍₁₎	6.5 ₍₃₎	2.71 ₍₃₎	10	P_(NC)
2021						
Little Lindley Cr. 1.2	50 ₍₃₎	7 ₍₁₎	5.7 ₍₅₎	2.72 ₍₃₎	12 _(NC)	P_(NC)
Little Lindley Cr. 2.5	53 ₍₃₎	9 ₍₁₎	6.2 ₍₃₎	1.77 ₍₃₎	10 _(NC)	P_(NC)

TR = Taxa Richness; EPTT = Ephemeroptera, Plecoptera, Trichoptera Taxa; BI = Biotic Index; SDI = Shannon Diversity Index; (#) subscript indicates individual metric scores.

When using CANDREF criteria, the Little Lindley Creek 0.9 EPTT metric scored higher in the spring of 2012. Although this resulted in a higher MSCI score, it did not change the support category, and the station remained partially supporting of the beneficial use criteria. No other stations had changes in MSCI score when assessed with CANDREF fall criteria.

6.2 Physicochemical Data Comparison

The comparison of fall physicochemical data among Little Lindley Creek stations is shown in Tables 22 and 23. The spring comparisons are shown in Tables 24 and 25.

Table 22. Fall Data Comparison of Discharge and *In Situ* Water Quality Measurements of Little Lindley Creek

Stations	Little Lindley Cr. 1.2	Little Lindley Cr. 3.0	Little Lindley Cr. 0.9	Little Lindley Cr. 2.5	Little Lindley Cr. 1.2	Little Lindley Cr. 2.5	Little Lindley Cr. 2.5 Duplicate
Parameters							
Sampling date and time	9/25/02; 0755	9/24/02; 1645	9/20/11; 1240	9/19/11; 1420	9/22/20; 1415	9/23/20; 1105	9/23/20; 1105
Dissolved Oxygen (mg/L)	6.20	10.10	9.15	9.52	12.71	11.51	11.54
pH (su)	7.4	7.9	7.8	8.1	8.76	8.49	8.51
Conductivity (µS/cm)	743	780	448	420	607	700	699
Temperature (°C)	16.0	18.5	18.4	19.5	19.6	18.2	18.2
Turbidity (NTU)	6.61	1.50	0.92	1.60	1.51	1.11	1.39
Discharge (cfs)	0.32	0.43	1.30	2.42	0.25	0.19	0.15

Values exceeding EPA's recommendations are in bold: 0.24 mg/L NO₂+NO₃-N; 0.38 mg/L TN; 0.007 mg/L TP; 1.4 NTU.

Dissolved oxygen was consistently above the WQS minimum criterion of 5.0 mg/L. Conductivity was lower during the 2011 bioassessment, but discharge was higher and likely provided more dilution of wastewater. Turbidity has exceeded EPA's recommended value of 1.4 NTU at least once during each study.

Table 23. Fall Data Comparison of Water Chemistry
Concentrations of Little Lindley Creek

Stations	Little Lindley Cr. 1.2	Little Lindley Cr. 3.0	Little Lindley Cr. 0.9	Little Lindley Cr. 2.5	Little Lindley Cr. 1.2	Little Lindley Cr. 2.5	Little Lindley Cr. 2.5 Duplicate
Parameters							
Sampling date and time	9/25/02; 0755	9/24/02; 1645	9/20/11; 1240	9/19/11; 1420	9/22/20; 1415	9/23/20; 1105	9/23/20; 1105
Nitrate+Nitrite as N (mg/L)	15.9	22.4	3.61	3.45	16.8^c	27.1^c	25.6^c
TKN	<0.2 ^a	<0.2 ^a	--	--	--	--	--
Total Nitrogen (mg/L)	--	--	3.83	4.05	17.2^c	28.2^c	27.7^c
Total Phosphorus (mg/L)	1.81	4.22	0.76	0.87	0.97	2.47	2.42
Ammonia as N (mg/L)	<0.05 ^a	<0.05 ^a	< 0.03 ^a	0.44	<0.2 ^a	0.04 ^b	0.04 ^b
Sulfate (mg/L)	--	--	--	--	20.1	23.0	22.6
Chloride (mg/L)	67.9	68.9	29.2	28.0	49.5	63.1	62.3
Total Suspended Solids (mg/L)	--	--	<5 ^a	<5 ^a	<5 ^a	<5 ^a	<5 ^a

Values exceeding EPA's recommendations are in bold: 0.24 mg/L NO₂+NO₃-N; 0.38 mg/L TN; 0.007 mg/L TP; 1.4 NTU.

^a not detected at reported value;

^b estimated values, detected below PQL;

^c sample diluted during analysis.

Nitrate plus nitrite-nitrogen, total nitrogen, and total phosphorus were elevated compared to EPA's recommended values in each fall sample. Nitrate plus nitrite-nitrogen and total nitrogen were elevated and required dilution for analysis during the most recent bioassessment.

Table 24. Spring Data Comparison of Discharge and *In Situ* Water Quality
Measurements of Little Lindley Creek

Stations	Little Lindley Cr. 1.2	Little Lindley Cr. 3.0	Little Lindley Cr. 0.9	Little Lindley Cr. 2.5	Little Lindley Cr. 1.2	Little Lindley Cr. 2.5
Parameters						
Sampling date and time	04/01/03; 1000	4/01/03; 0820	3/19/12; 1145	3/19/12; 1000	4/15/21; 1150	4/15/21; 1315
Dissolved Oxygen (mg/L)	12.00	7.80	11.49	9.69	14.9	16.05
pH (su)	8.27	7.88	8.5	8.3	7.6	9.01
Conductivity (µS/cm)	412	422	467	497	339	344
Temperature (°C)	11.5	10.0	19.2	17.5	13.7	14.7
Turbidity (NTU)	5.75	7.80	1.04	1.42	1.88	1.74
Discharge (cfs)	6.28	5.08	3.68	1.76	6.03	4.57

Values exceeding EPA's recommendations are in bold: 0.24 mg/L NO₂+NO₃-N; 0.38 mg/L TN; 0.007 mg/L TP; 1.4 NTU.

Dissolved oxygen was consistently above the WQS minimum criterion of 5.0 mg/L. Conductivity was similar during the first two bioassessments, 2003 and 2012, but lower during the current bioassessment. Turbidity exceeded EPA's recommended value of 1.4 NTU during all sampling events except the downstream station in 2012. Turbidity was highest during 2003.

Table 25. Spring Data Comparison of Water Chemistry
Concentrations of Little Lindley Creek

Stations	Little Lindley Cr. 1.2	Little Lindley Cr. 3.0	Little Lindley Cr. 0.9	Little Lindley Cr. 2.5	Little Lindley Cr. 1.2	Little Lindley Cr. 2.5
Parameters						
Sampling date and time	4/01/03; 1000	4/01/03; 0820	3/19/12; 1145	3/19/12; 1000	4/15/21; 1150	4/15/21; 1315
Nitrate+Nitrite as N (mg/L)	1.08	4.43	1.93	4.27	1.112	1.717
TKN	0.34	0.54	---	---	---	---
Total Nitrogen (mg/L)	---	---	2.46	5.11	1.32	1.98
Total Phosphorus (mg/L)	0.41	0.45	0.425	0.67	0.12	0.19
Ammonia as N (mg/L)	<0.05 ^a	<0.05 ^a	<0.3 ^a	0.04 ^b	<0.02 ^a	<0.02 ^a
Sulfate (mg/L)	---	---	---	---	9.71	9.72
Chloride (mg/L)	34.8	39.1	32.8	38.9	17.5	22.4
Total Suspended Solids (mg/L)	---	---	<5 ^a	<5 ^a	<5 ^a	<5 ^a

Values exceeding EPA's recommendations are in bold: 0.24 mg/L NO₂+NO₃-N; 0.38 mg/L TN; 0.007 mg/L TP; 1.4 NTU.

^a not detected at reported value;

^b estimated values, detected below PQL.

Nitrate plus nitrite-nitrogen, total nitrogen, and total phosphorus were elevated compared to EPA's recommended values during each spring sampling event. No dilutions were required during for the spring samples, and phosphorus was lower than the fall samples.

7.0 Discussion

7.1 Land Use

Little Lindley Creek originates in Dallas County just north of the City of Buffalo. Buffalo's WWTF discharges into Little Lindley Creek approximately 0.5 miles downstream of State Highway 65 near the city limits of Buffalo. The stream has little to no flow upstream of the WWTF outfall. Little Lindley Creek then flows northwest approximately four miles to its confluence with Lindley Creek. Urbanization and pasture combine to make up over 70 percent of the land use at the test stations. A study from North Carolina comparing three streams of similar catchment size but with different land use types (forest, agriculture, and urban) found that fewer EPT taxa and more tolerant taxa occurred in streams in agricultural versus forested landscapes, indicating a moderate level of stress to aquatic communities in agricultural systems (Lenat and Crawford 1994). Lenat and Crawford (1994) also found that streams in urban settings exhibit low taxa richness, low abundance, and high biotic index values.

Agricultural land use in a watershed is a major contributor of sediment and nutrient runoff into aquatic systems (Harding et al. 1999, Burdon et al. 2013). Both Lindley Creek

and Little Lindley Creek's watersheds are mostly pastureland (ranging from 61 percent to 71 percent), with cattle having direct access to the streams. Cattle urine, either through direct inputs to water or leaching from adjacent pastureland, is a source of inorganic nutrients to streams (Braccia et al. 2006). Excessive nutrient loads stimulate primary production, causing streambeds to become covered with algae. Excessive algal growth and fungus on streambeds eliminate physical habitat for taxa that require clean substrates for attachment.

Urbanization affects the quantity and quality of water in a watershed by altering the natural flow of rainwater, making streams and rivers more susceptible to extreme flooding events (Tang et al. 2005; Walsh et al. 2005). Although the percent of urban/impervious land use in the Lindley Creek watershed is comparable to the overall EDU, Little Lindley Creek's watershed contains almost three times as much urban/impervious surface compared to the EDU. Streams in urban and agricultural areas tend to have increased concentrations of nutrients and contaminants as well as macroinvertebrate communities with reduced biotic richness and increased dominance of tolerant taxa (Allan 2004, Walsh et al. 2005).

7.2 Stream Habitat Assessment

Instream habitat variables as well as catchment variables have been shown to influence aquatic communities (Wang et al. 2007, Burdon et al. 2013). Although the substrate of the test streams did contain some areas of cobble and gravel, they had minimal submerged vegetation, woody debris, and undercut banks. Riffles were of marginal quality at all test stations, and pool variability was lacking. All stations had areas of exposed bedrock instream, which limited macroinvertebrate habitat availability. Little Lindley Creek 2.5 had extensive areas of bedrock. Burdon et al. (2013) determined sensitive taxa are more strongly associated with benthic habitat than with food resources. Lack of benthic habitat therefore limits sensitive taxa. Lammert and Allan (1999) showed that channel morphology and substrate were vital to healthy macroinvertebrate communities.

Riparian vegetation positively influences stream ecosystems directly by shading and litter inputs, and indirectly by reducing nutrients and other contaminants entering the system from the surrounding landscape (Burrell et al. 2013). Riparian corridors were poor at each station in this study. Pastures were prevalent, and cattle had direct access to the study streams. Cattle grazing in the riparian zones also reduced vegetation growth. Trampling of vegetative undergrowth and trenches created by cattle accessing the stream damage stream banks and increase erosion of the banks (Roche 2002-2003). Intact riparian zones along stream banks are important for maintaining stream health, stream habitat, and good water quality (Allan 2004, Waite and Van Metre 2017).

7.3 Biological Assessment and Macroinvertebrate Community Analyses

Comparison of Biological Criteria References and Candidate References

When assessing Lindley Creek and Little Lindley Creek using BIOREF versus CANDREF biological criteria, the test streams scored within the same support category for both sets of criteria with the exception of Lindley Creek 19.5. Due to a lower CANDREF BI scoring threshold value, this station changed from a fully supporting score of 16 to a partially supporting score of 14 during the fall.

The most notable difference in metrics between the two sets of criteria for the fall data was the lower BI threshold for the CANDREF data set. TR, EPTT, and SDI had minimal changes to their threshold values. The most notable difference in the spring was a higher EPTT threshold value in the CANDREF data set. However, all test stations had few enough EPTT that this did not affect their MSCI scores.

Percent Composition of Intolerant Taxa

Based on the comparison of percent intolerant to tolerant taxa and the overall macroinvertebrate community composition, the macroinvertebrate communities of Lindley and Little Lindley creeks were dominated by moderately tolerant (BI range 5.0-7.4) to tolerant (BI range 7.5-8.9) taxa. TR and EPTT values were higher in Lindley Creek than Little Lindley Creek, but not high enough to score optimally. Poulton and Tao (2020) observed a decline in EPT abundance and richness at sites affected by urbanization and point sources. The mayfly families Heptageniidae and Baetidae were more abundant at Lindley Creek 19.5, the most downstream test station. Caenidae was more abundant in Lindley Creek 20.9 and Little Lindley Creek 1.2. The common mayfly taxa collected throughout the study have BI values >5.0. Taxa with high BI values are often associated with organic and nutrient pollution (Hilsenhoff 1987).

Dyer and Wang (2002) reported declines in EPTT, and Suckling (1982) reported increases in hydropsychid caddisflies downstream of WWTF outfalls. This was apparent in the fall data, particularly with hydropsychid caddisflies, which were absent from Lindley Creek 20.9, the only station that lacks influence from the WWTF. In the spring, Little Lindley Creek had fewer EPTT than Lindley Creek, but Hydropsychidae was not abundant at any of the test stations. Effects from urban areas and WWTFs have been shown to contribute to declines in aquatic communities and biotic integrity. Runoff from impervious surfaces and point source discharges result in contaminants and excessive nutrient influxes into waterways, causing taxa richness declines in aquatic communities (Paul and Meyer 2001).

Percent Composition of Functional Feeding Groups

Because FFGs respond to inputs into aquatic systems, stressed aquatic conditions are often manifested in FFG categories. Specialist FFG categories have specific feeding needs that may be limited in impaired systems, whereas generalist FFGs are thought to be more tolerant due to their ability to use a wider array of available food resources. Generalist categories, such as gatherer-collectors and filterer-collectors, increase in

response to increased pollution or disturbances while specialists such as scrapers decrease (Barbour et al. 1999).

During the fall, test station FFG categories did not differ drastically from BIOREF data. Filterer-collectors and gatherer-collectors made up 56 percent of the aggregate of BIOREF communities, and they ranged from 53 to 70 percent among test stations. During the spring, filterer-collectors and gatherer-collectors dominated the test station communities. These two FFGs accounted for 52 percent of the community of BIOREF stations and between 58 percent at Little Lindley Creek 1.2 to 90 percent of the community at Little Lindley Creek 2.5. At Lindley Creek, these two FFGs made up almost 70 percent of the community. Fewer FFG categories dominated the Little Lindley Creek stations in spring. The fall data showed a better distribution among categories. Generally, Little Lindley Creek stations with the most urbanized land use and WWTF inputs exhibited patterns of a stressed community when considering FFG trends.

7.4 Physicochemical Water Parameters

In situ water quality measurements were consistent for each sampling season. Discharge was significantly lower during the fall compared to spring. Dissolved oxygen was above the WQS minimum of 5.0 mg/L during both bioassessment sampling events. During the fall, conductivity was elevated in Little Lindley Creek, the receiving stream of the Buffalo WWTF discharge. Chloride and sulfate were higher in the fall, likely due to the lower flow resulting in less dilution and higher relative concentrations of effluent instream. Despite these higher concentrations, chloride and sulfate did not exceed the chronic WQS criteria (MoDNR 2018f) for either season.

Nutrient concentrations were elevated at all test stations during both seasons, with the exception of nitrate plus nitrite as N at Lindley Creek 20.9 during the fall. High levels of nutrients result in degraded aquatic communities (Dodds et al. 2009, Waite and Van Metre 2017, Wang et al. 2007). Nutrient concentrations were notably higher in Little Lindley Creek than Lindley Creek in fall compared to the spring and required dilution for analysis. During the fall, nitrate plus nitrite as N was highest at the test station nearest the WWTF (27.1 mg/L) and decreased as sampling continued downstream of the facility. Total nitrogen and total phosphorus exhibited a similar trend with higher concentrations in Little Lindley Creek. At the test station nearest the WWTF, total nitrogen was 28.2 mg/L and total phosphorus was 2.47 mg/L. The lower discharge in the fall likely contributed to higher nutrient values by having less stream flow available for wastewater dilution and thus causing nutrients to be concentrated. In contrast, spring nutrient values were likely diluted by spring rain. Spring nutrient values were higher than EPA's recommended values but did not require dilution during analysis. At the test station nearest the WWTF, nitrate plus nitrite as N was 1.717 mg/L, total nitrogen was 1.98 mg/L, and total phosphorus was 0.19 mg/L.

During the WLA study of summer 2020, nitrate plus nitrite as N and total nitrogen had to be diluted at all three Little Lindley Creek stations sampled downstream of the WWTF:

13.8 mg/L, 16.1 mg/L, 1.51 mg/L from upstream to downstream, respectively (MoDNR 2021). The highest nutrient values recorded during the WLA occurred in a sample collected in the afternoon of August 11. Nitrate plus nitrite as N, total nitrogen, and total phosphorus were highest at station 2.5, the station located at the mid-section of the WLA sampling reach. During the morning of August 13, total nitrogen was elevated (12.0 mg/L) and required dilution at the station located upstream of the WWTF. Elevated nutrients are mostly a result of the point source, but water quality results indicate that non-point sources are also a factor.

Although Missouri does not have nutrient criteria for streams and rivers, nutrient concentrations in the test streams were well above EPA's recommended values (USEPA 2000). Nutrient enrichment can lead to secondary effects on macroinvertebrates such as excessive algae growth, increases in suspended fine particulate organic matter, and sediment retention (Graham 1990). Previous studies have also reported declines in EPTT (Dyer and Wang 2002), increases in hydropsychid caddisflies (Suckling 1982), and increases in the nutrient-tolerant chironomids *Dicrotendipes* and *Cricotopus/Orthocladius* group (Jacobsen 2008). Compared to BIOREF and CANDREF conditions, Lindley Creek and Little Lindley Creek test stations had lower TR and EPTT, a higher percentage of hydropsychid caddisflies in fall samples, and higher *Dicrotendipes* and *Cricotopus/Orthocladius* group abundance (especially in fall). Excessive nutrients have been identified as a major reason for failure of water quality objectives, such as support of aquatic life (USEPA 2000).

7.5 Data Logger Deployment

Multiparameter water quality loggers were deployed during the summer of 2020 at locations corresponding with the Little Lindley Creek WLA (MoDNR 2021). Data logger deployment determined that DO does fall below 5.0 mg/L when algal respiration consumes oxygen during the overnight hours. The lowest DO value (4.53 mg/L) was recorded at the station closest to the WWTF. Farther downstream in Little Lindley Creek, DO had a minimum value of 6.59 mg/L. Both stations had benthic algae present instream and ample shade coverage of the stream. At both stations, loggers were located near the end of riffles where the water was thoroughly mixed.

Lindley Creek data loggers were also deployed at the bottom of riffle areas with thorough mixing. At Lindley Creek 19.5, DO was below the minimum of 5.0 mg/L a quarter of the time, and at station 20.9, DO was below the minimum half of the time. Both stations were wider than Little Lindley Creek and had more sun exposure. The wider channel led to areas of more stagnant flow. Station 20.9, upstream of the Little Lindley Creek confluence, had excessive algal growth instream.

Low DO levels can be detrimental to aquatic organisms (Allan 1995, Rounds et al. 2013). Low oxygen levels can occur near the bottom of the water column, thus affecting the benthic community. Taxa with high BI values are often associated with organic and nutrient pollution, which can cause low DO conditions (Hilsenhoff 1987).

Two of the CANDREF stations had DO readings below 5.0 mg/L during the deployment period. Macks Creek was below 5.0 mg/L less than 10 percent of the time, and Saline Creek was below 5.0 mg/L a quarter of the time. Logger placement may have affected the Saline Creek results. This logger was placed near the outer margin of a riffle area at the Saline Valley Conservation Area in an attempt to make it less visible to people who recreate at the area. It is possible that there was less mixing in this deployment area compared to stations in which loggers were placed downstream of riffles but more toward the middle of the channel.

Conductivity, a measure of the ability of an aqueous solution to carry an electric current, is affected by the presence of inorganic dissolved solids. Higher conductivity measurements may identify influences that can degrade the aquatic community (MoDNR 2018d). For example, discharges of wastewater to streams can increase the conductivity of a stream due to the presence of inorganic dissolved solids as well as other constituents such as sulfate and chloride. Data logger readings showed that conductivity was higher in Little Lindley Creek compared to Lindley Creek. The mean conductivity values in Lindley Creek were in the mid-400s, and Little Lindley Creek's mean was in the mid to upper-500s. Alternatively, storm water events can cause dilution of dissolved ions resulting in a decrease in conductivity, which was seen in Macks Creek and Saline Creek during the data logger deployment.

An unusual set of readings started on August 16 at 6:30 A.M. at Lindley Creek 19.5. There was a rapid decrease in conductivity, but at 7:30 P.M. it returned to near its previous reading (Figure 12). The data logger was deployed on private property approximately 75 yards upstream of a bridge crossing and located upstream of an unnamed tributary entering from the north. The logger was situated such that neither the bridge nor the tributary would have affected the readings. The cause of this fluctuation is unknown, but these drastic changes in readings were not typical of natural events, such as storm water flows (e.g. as seen in Figure 17). The pattern seen on August 16 was similar to readings caused by debris being temporarily caught on the logger's protective housing or the sensor itself.

7.6 Water Quality Duplicate Sample Results

Duplicate sample difference criteria for physicochemical parameters were exceeded twice during this study. Discharge exceeded the 20 percent relative percent difference at Little Lindley Creek 2.5 in fall 2020. Duplicate discharge values were 0.15 cfs and 0.19 cfs, a 23 percent difference, but an absolute difference of 0.04 cfs. The precision of analysis, along with these being very low discharge measurements, left little room for deviation between values. Turbidity values exceeded the relative percent difference during the same sampling event at Little Lindley Creek. The values were 1.39 NTU and 1.11 NTU, a 22 percent difference. Neither value exceeded EPA's recommended 1.4 NTU for the Ozark Highlands Ecoregion. Even though the values exceed the relative percent difference, the values were low, and the water did not appear turbid during sampling. A

review of collection and analysis methods did not reveal any apparent reason for the differences.

7.7 Data Trends

Flow is one of the significant variables limiting macroinvertebrate communities (Hynes 1970). During the fall bioassessment sampling periods, the higher MSCI scores attained in 2011 occurred when discharge was higher among stations. However, no such trend was observed with spring macroinvertebrate samples.

Fall SDI values have shown improvement since the first assessment of 2002-2003; however, spring SDI values have stayed the same or decreased slightly over time. SDI is a measure of community composition, taking both richness and evenness into account (Shannon and Weaver 1949). Department assessment procedures assume that a more diverse community is a more healthy community. It is not uncommon for Chironomidae to be much more abundant in spring bioassessment samples compared to fall (MoDNR unpublished data). When this occurs, the dominance of this one family will decrease SDI values.

A comparison of water quality data from all three bioassessments showed that nutrient concentrations have remained elevated over time in Little Lindley Creek, with the highest concentrations occurring during the fall of the current study. Based on these multiple years of study, nutrient enrichment appears to be a chronic issue in Little Lindley Creek. Even stations without wastewater inputs (Lindley Creek 20.9 and Little Lindley Creek WLA station 0.9 [MoDNR 2021]) had high levels of nutrients, which indicates nonpoint pollutant sources in the watershed. Excessive nutrients have been identified as a major reason for streams failing to meet water quality objectives, such as the support of aquatic life (USEPA 2000).

Nutrient enrichment can lead to excess algal and phytoplankton production, which in turn can result in diurnal patterns of dissolved oxygen extremes (Wetzel 1983). Based on data sonde results, however, stations downstream of the Buffalo WWTF had fewer instances of DO <5.0 mg/L than the station without effluent input. Little Lindley Creek 2.5, the first station downstream of the WWTF outfall, had no readings with DO <5.0 mg/L. In fall 2020, stations without WWTF effluent had very little discharge. The additional flow from the facility may have led to increased turbulence in riffles, thereby helping to aerate the receiving stream as well as the effluent itself likely having higher DO concentrations than the receiving stream due to aeration during the wastewater treatment process.

Despite long term nutrient enrichment in the system, Little Lindley Creek BI values have improved since the initial bioassessment in 2002. Although the BI metric tends to increase with increased organic pollution such as those found in wastewater (Hilsenhoff 1987), BI values were not consistently higher for sampling locations with effluent inputs. Lower BI values may result from the presence of taxa that are more responsive to low DO concentrations than they are to higher nutrient concentrations.

Overall, using streams of similar size (CANDREF) resulted in no difference compared with using BIOREF data. With the exception of a single sampling event in fall 2011, the MSCI support category was the same with either comparison.

8.0 Conclusion

Both test streams, Lindley Creek and Little Lindley Creek, exhibited signs of degraded conditions in terms of habitat quality, watershed land use, and water quality. Even when evaluating these stations using reference quality streams of similar size, they did not consistently attain optimal MSCI scores to indicate full support of the protection of warm water habitat beneficial use designation. Land use features such as urbanization and cattle pastures (the majority of the land use), in combination with WWTF effluent, are probable factors that led to a macroinvertebrate community composed primarily of moderately tolerant to tolerant taxa.

Little Lindley Creek has been the subject of three separate bioassessments. TR and EPTT have remained suboptimal, but BI and SDI have maintained higher values since WWTF upgrades occurred. Although individual biological metric values have improved, the test stations still do not score optimally on a consistent basis. This system shows effects of landscape alterations such as urbanization and agriculture. The macroinvertebrate community would likely take decades to recover from land use effects even if restoration efforts (e.g. livestock exclusion, riparian corridor restoration) were implemented (Harding et al. 1998).

9.0 Literature Cited

- Allan, J.D. 1995. Stream Ecology. Chapman and Hall, London. 388 pp.
- Allan, J.D. 2004. Landscapes and Riverscapes: the influence of land use on stream ecosystems. *Annual Review of Ecology, Evolution, and Systematics* 35: 257-284.
- Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. (1999) Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers—Periphyton, Benthic Macroinvertebrates, and Fish. 2nd Edition, EPA 841/B-99/002, USEPA, Washington DC.
- Braccia, A., and R. Voshell Jr. 2006. Benthic Macroinvertebrate Fauna in Small Streams Used by Cattle in the Blue Ridge Mountains, Virginia. *Northeastern Naturalist* 13(2): 269-286.
- Burdon, F.J., A.R. McIntosh, and J.S. Harding. 2013. Habitat loss drives threshold response of benthic invertebrate communities to deposited sediment in agricultural streams. *Ecological Applications* 23(5): 1036-1047.
- Burrell, T.K., J.M. O'Brien, S.E. Graham, K.S. Simon, J.S. Harding, and A.R. McIntosh. 2013. Riparian Shading mitigates Stream Eutrophication in Agricultural Catchments. *Freshwater Science* 33(1): 73-84.
- Dodds, W.K., W.W. Bouska, J.L. Eitsmann, T.J. Pilger, K.L. Pitts, A.J. Riley, and D.J. Thornbrugh. 2009. Eutrophication of U. S. Freshwaters: Analysis of Potential Economic Damages. *Environmental Science and Technology* 43(1): 12-19.
- Dyer, S.D. and X. Wang. 2002. A Comparison of Stream Biological Responses to Discharges from Wastewater Treatment Plants in High and Low Population Density Areas. *Environmental Toxicology and Chemistry* 21: 1065-1075.
- Graham, A.A. 1990. Siltation of Stone-Surface Periphyton in Rivers by Clay-Sized Particles from Low Concentrations in Suspension. *Hydrobiologia* 199:107-115.
- Harding, J.S., E.F. Benfield, P.V. Bolstad, G.S. Helfman, and E.B.D. Jones III. 1998. Stream Biodiversity: The ghost of land use past. *Proceeding of the National Academy of Sciences, USA*. 95: 14843-14847.
- Harding, J.S., R.G. Young, J.W. Hayes, K.A. Shearer, and J.D. Stark. 1999. Changes in agricultural intensity and river health along a river continuum. *Freshwater Biology* 42: 345-357.
- Hilsenhoff, W.L. 1987. An improved biotic index of organic stream pollution. *The Great Lakes Entomologist* 20(1): 31-39.

- Hynes, H. B. N. 1970. *The Ecology of Running Waters*. University of Toronto Press, Toronto. 55pp.
- Jacobsen, R.E. 2008. Midge (Diptera: Chironomidae and Ceratopogonidae) Community Response to Canal Discharge into Everglades National Park, Florida. *Proceedings of the 16th International Chironomid Symposium* 13:39-50.
- Lammert, M. and J.D. Allan. 1999. Assessing biotic integrity of streams: effects of scale in measuring the influence of land use/cover and habitat structure on fish and macroinvertebrates. *Environmental Management* 23: 257-270.
- Lenat, D.R. and J.K. Crawford. 1994. Effects of Land Use on Water Quality and Aquatic Biota of Three North Carolina Piedmont Streams. *Hydrobiologia* 294: 185-199.
- Missouri Department of Natural Resources. 2002. *Biological Criteria for Wadeable/Perennial Streams of Missouri*. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 32 pp.
- Missouri Department of Natural Resources. 2003. *Biological Assessment Study, Little Lindley Creek, Dallas County*. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 60 pp.
- Missouri Department of Natural Resources. 2007a. *City of Buffalo's State Operating Permit In Lieu of Total Maximum Daily Load*. Missouri Department of Natural Resources, Water Protection Program, P.O. Box 176, Jefferson City, Missouri. 3p.
- Missouri Department of Natural Resources. 2007b. *TMDL Information Sheet, Little Lindley Creek*. Missouri Department of Natural Resources, Water Protection Program, P.O. Box 176, Jefferson City, Missouri. 3 p.
- Missouri Department of Natural Resources. 2012. *Biological Assessment Study, Little Lindley Creek, Dallas County*. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 80 pp.
- Missouri Department of Natural Resources. 2016. *Standard Operating Procedure MDNR-ESP-213. Quality Control Procedures for Checking Water Quality Field Instruments*. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 17pp.

- Missouri Department of Natural Resources. 2018a. Standard Operating Procedure MDNR-ESP-012. Analysis of Turbidity Using the Hach 2100P and 2100Q Portable Turbidimeter. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 13 pp.
- Missouri Department of Natural Resources. 2018b. Standard Operating Procedure MDNR-ESP-100. Field Analysis of Water Samples for pH. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 8 pp.
- Missouri Department of Natural Resources. 2018c. Standard Operating Procedure MDNR-ESP-101. Field Measurement of Water Temperature. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 4 pp.
- Missouri Department of Natural Resources. 2018d. Standard Operating Procedure MDNR-ESP-102. Field Analysis of Specific Conductance in Water. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 9 pp.
- Missouri Department of Natural Resources. 2018e. Standard Operating Procedure MDNR-ESP-104. Continuous Monitoring of Water Quality using a Dissolved Oxygen, Specific Conductance, PH, Turbidity, Rhodamine Dye, and Temperature Data Logger. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 18 pp.
- Missouri Department of Natural Resources. 2018f. Title 10. Rules of Department of Natural Resources Division 20-Clean Water Commission, Chapter 7-Water Quality. 10 CSR 20-7.031 Water Quality Standards. pp. 11-129.
- Missouri Department of Natural Resources. 2019a. Methodology for the Development of the 2020 Section 303 (d) List in Missouri, Final July 22, 2019. Prepared by the Missouri Department of Natural Resources, Division of Environmental Quality, Water Protection Program, P.O. Box 176, Jefferson City, Missouri 65102. 110 pp.
- Missouri Department of Natural Resources. 2019b. Semi-Quantitative Macroinvertebrate Stream Bioassessment Project Procedure. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 29 pp.
- Missouri Department of Natural Resources. 2019c. Standard Operating Procedure MDNR-ESP-103. Field Analysis of Dissolved Oxygen Using Meters. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 11 pp.

- Missouri Department of Natural Resources. 2019d. Standard Operating Procedure MDNR-ESP-209. Taxonomic Levels for Macroinvertebrate Identifications. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 40 pp.
- Missouri Department of Natural Resources. 2019e. Standard Operating Procedure MDNR-ESP-210. Quality Assurance/Quality Control for Environmental Data Collection. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 13 pp.
- Missouri Department of Natural Resources. 2019f. Standard Operating Procedure MDNR-ESP-214. Quality Control Procedures for Data Processing. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 7 pp.
- Missouri Department of Natural Resources. 2019g. Stream Habitat Assessment Project Procedure. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 40 pp.
- Missouri Department of Natural Resources. 2020a. Quality Assurance Project Plan for Biological Assessment, LDPR Code FEBIO, FETSW, & FECLC. State Fiscal Year 2019. Prepared by the Missouri Department of Natural Resources, Division of Environmental Quality, Water Protection Program, P.O. Box 176, Jefferson City, Missouri 65102. 24 pp.
- Missouri Department of Natural Resources. 2020b. Standard Operating Procedure MDNR-ESP-001. Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 29 pp.
- Missouri Department of Natural Resources. 2020c. Standard Operating Procedure MDNR-ESP-113. Flow Measurements in Open Channels. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 16 pp.
- Missouri Department of Natural Resources. 2021. Wasteload Allocation Stream Sampling Report. Buffalo WWTF. Little Lindley Creek, Dallas County. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 57 pp.

- Missourinet (a division of Learfield News & Ag, LLC). 2008. Petit Jean Poultry to Close, 400 Jobs Lost. <https://www.missourinet.com/2008/09/25/petit-jean-poultry-plant-to-close-400-jobs-lost/>. Website accessed March 2, 2023.
- Paul, M.J. and J.L. Meyer 2001. Streams in the urban landscape. *Annual Review of Ecology and Systematics* 32: 333–365.
- Poulton, B.C. and J. Tao. 2020. Evaluation of EPT macroinvertebrate metrics in small streams located within the non-connected stormwater management region of Kansas City, Missouri, USA. *Transactions of the Missouri Academy of Science* 47: 21-34.
- Rabeni, C.F., N. Wang, and R.J. Sarver. 1999. Evaluating Adequacy of the representative Stream Reach used in Invertebrate Monitoring Programs. *Journal of the North American Benthological Society* 18: 284-291
- Roche, L. 2002-2003. A Review of Livestock Impacts on Riparian Ecosystems: Vegetative and Aquatic Consequences and Grazing Management. UC Davis: Prized Writing; The Essay and Scientific and Technical Writing 2002-2003.
- Rounds, S.A., F.D. Wilde, and G.F. Ritz. 2013. Dissolved oxygen (ver. 3. 0): U. S. Geological Survey Techniques of Water-Resources Investigations, Book 9, Chap. A6, Sec. 6. 2.
- Shannon, C. E. and W. W. Weaver. 1949. The mathematical theory of communication. University of Illinois Press, Urbana. 125pp.
- Sowa, S.P., D.D. Diamond, R.A. Abbitt, G.M. Annis, T. Gordon, M E. Morey, G.R. Sorensen, and D. True. 2004. Final Report of the Aquatic Component of GAP Analysis: A Missouri Prototype. Missouri Resource Assessment Partnership (MoRAP), University of Missouri. 111 pp.
- Suckling, D.M. 1982. Organic Wastewater Effects on Benthic Invertebrates in the Manawatu River. *New Zealand Journal of Marine and Freshwater Research* 16: 263-270.
- Tang Z., B.A. Engel, B.C. Pijanowski, and K.J. Lim. 2005. Forecasting land use change and its environmental impact at a watershed scale. *Journal of Environmental Management* 76: 35-45.
- United States Geological Survey. 2019. National Land Cover Database (NLCD) 2019 Products. <https://www.usgs.gov/data/national-land-cover-database-nlcd-2019-products>. Accessed 15 November 2022.

- United States Environmental Protection Agency. 2000. Ambient Water Quality Criteria Recommendations. Information Supporting the Development of State and Tribal Nutrient Criteria for Rivers and Streams in Nutrient Ecoregion XI. EPA 822-B-00-020. 99 pp.
- Walsh, C.J., A.H. Roy, J.W. Feminella, P.D. Cottingham, P.M. Groffman, and R.P. Morgan III. 2005. The urban stream syndrome; current knowledge and the search for a cure. *Journal of the North American Benthological Society* 24(3): 706-723.
- Waite I.R. and P.C. Van Metre. 2017. Multistressor predictive models of invertebrate condition in the Corn Belt, USA. *Freshwater Science* 36(4): 901-914.
- Wang, L., D.M. Robertson, and P.J. Garrison. 2007. Linkages between nutrients and assemblages of macroinvertebrates and fish in wadeable streams: Implication to nutrient criteria development. *Environmental Management* 39: 194-212.
- Wetzel, R.G. 1983. *Limnology*, 2nd Edition. Saunders College Publishing, Philadelphia, PA 19105.

Submitted by: Brandy Bergthold
Brandy Bergthold
Environmental Program Analyst
Water Quality Monitoring Section
Environmental Services Program

Date: June 13, 2024

Approved by: Scott Robinett
Scott Robinett
Water Quality Monitoring Section Chief
Environmental Services Program

SR:bb

c: Robert Voss, WPP
Tanya Turner, SWRO

Appendix A

Fall and Spring Metric Values and Scores for Candidate Reference Streams
Using Ozark/Osage Biological Criteria.

Separated by Season

Fall Metric Values and Scores for Candidate Reference Streams
Using Ozark/Osage Biological Criteria

Stations	Year	TR	EPTT	BI	SDI	MSCI	Support
Barren Fork ¹	2002	84 ₍₃₎	20 ₍₅₎	5.9 ₍₅₎	3.31 ₍₅₎	18	F
Brush Creek ¹	1995	89 ₍₅₎	25 ₍₅₎	5.7 ₍₅₎	3.24 ₍₅₎	20	F
Brush Creek ¹	2020	89 ₍₅₎	21 ₍₅₎	5.3 ₍₅₎	3.4 ₍₅₎	20	F
Deer Creek ²	1996	105 ₍₅₎	24 ₍₅₎	5.5 ₍₅₎	3.72 ₍₅₎	20	P
Deer Creek ²	1996	97 ₍₅₎	27 ₍₅₎	5.5 ₍₅₎	3.51 ₍₅₎	20	F
Deer Creek ²	2000	84 ₍₃₎	20 ₍₅₎	5.4 ₍₅₎	3.29 ₍₅₎	18	F
Deer Creek ²	2002	106 ₍₅₎	25 ₍₅₎	5.7 ₍₅₎	3.99 ₍₅₎	20	F
Dry Fork ¹ *	2003	59 ₍₃₎	9 ₍₃₎	5.4 ₍₅₎	2.9 ₍₃₎	14	P
Ingalls Creek ¹	2011	76 ₍₃₎	20 ₍₅₎	6.4 ₍₅₎	2.98 ₍₃₎	16	F
Macks Creek ¹	2002	87 ₍₅₎	25 ₍₅₎	5.8 ₍₅₎	3.48 ₍₅₎	20	F
Macks Creek ¹	2020	101 ₍₅₎	32 ₍₅₎	5.7 ₍₅₎	3.58 ₍₅₎	20	F
North Dry Sac R. ¹	2020	79 ₍₃₎	25 ₍₅₎	3.7 ₍₅₎	2.91 ₍₃₎	16	F
Saline Creek ²	2000	84 ₍₃₎	20 ₍₅₎	6.4 ₍₅₎	3.38 ₍₅₎	18	F
Saline Creek ²	2020	104 ₍₅₎	26 ₍₅₎	6.4 ₍₅₎	3.53 ₍₅₎	20	F
Saline Creek ²	1999	99 ₍₅₎	27 ₍₅₎	6.7 ₍₃₎	3.37 ₍₅₎	18	F
Starks Creek ¹	2002	98 ₍₅₎	21 ₍₅₎	6.1 ₍₅₎	3.67 ₍₅₎	20	F
Starks Creek ¹	2020	87 ₍₅₎	22 ₍₅₎	5.7 ₍₅₎	3.46 ₍₅₎	20	F
BIOREF Score=5	---	>84	>19	<6.6	>3.23	20-16	Full
BIOREF Score=3	---	84-42	19-9	6.6-8.3	3.23-1.61	14-10	Partial
BIOREF Score=1	---	<42	<9	>8.3	<1.61	8-4	Non

MSCI Scoring Table (in light gray) developed from BIORREF streams ($n = 28$). TR = Taxa Richness; EPTT = Ephemeroptera, Plecoptera, Trichoptera Taxa; BI = Biotic Index; SDI = Shannon Diversity Index; Individual metric scores in (). *Dry Fork 2003 – only CS and NF habitats were sampled.

¹ = CANDREF Stream; ² = BIORREF Stream

Spring Metric Values and Scores for Candidate Reference Streams
Using Ozark/Osage Biological Criteria

Stations	Year	TR	EPTT	BI	SDI	MSCI	Support
Barren Fork ¹	2003	108 ₍₅₎	33 ₍₅₎	5.9 ₍₅₎	3.59 ₍₅₎	20	F
Brush Creek ¹	1995	107 ₍₅₎	36 ₍₅₎	6.2 ₍₃₎	3.3 ₍₅₎	18	F
Brush Creek ¹	2021	101 ₍₅₎	31 ₍₅₎	5.3 ₍₅₎	3.56 ₍₅₎	20	F
Deer Creek ²	1996	89 ₍₃₎	26 ₍₅₎	6.1 ₍₃₎	3.1 ₍₃₎	14	P
Deer Creek ²	1996	108 ₍₅₎	32 ₍₅₎	6 ₍₅₎	3.43 ₍₅₎	20	F
Deer Creek ²	2000	111 ₍₅₎	32 ₍₅₎	6.1 ₍₃₎	3.43 ₍₅₎	18	F
Deer Creek ²	2000	110 ₍₅₎	27 ₍₅₎	6.1 ₍₃₎	3.44 ₍₅₎	18	F
Deer Creek ²	2003	113 ₍₅₎	31 ₍₅₎	5.5 ₍₅₎	3.89 ₍₅₎	20	F
Dry Fork ¹	2004	102 ₍₅₎	23 ₍₅₎	5.5 ₍₅₎	3.43 ₍₅₎	20	F
Ingalls Creek ¹	2003	77 ₍₃₎	16 ₍₃₎	5.5 ₍₅₎	2.87 ₍₃₎	14	P
Ingalls Creek ¹	2012	91 ₍₅₎	25 ₍₅₎	5.3 ₍₅₎	3.29 ₍₅₎	20	F
Macks Creek ¹	2003	96 ₍₅₎	30 ₍₅₎	5.8 ₍₅₎	3.49 ₍₅₎	20	F
Macks Creek ¹	2021	88 ₍₃₎	34 ₍₅₎	5.3 ₍₅₎	3.28 ₍₅₎	18	F
North Dry Sac R. ¹	2021	78 ₍₃₎	29 ₍₅₎	3.8 ₍₅₎	3.11 ₍₃₎	16	F
Saline Creek ²	1999	90 ₍₃₎	30 ₍₅₎	6.2 ₍₃₎	2.85 ₍₃₎	14	P
Saline Creek ²	2008	79 ₍₃₎	20 ₍₃₎	5.5 ₍₅₎	3.17 ₍₃₎	14	P
Saline Creek ²	2021	87 ₍₃₎	27 ₍₅₎	6 ₍₅₎	3.32 ₍₅₎	18	F
Saline Creek ²	2000	93 ₍₅₎	27 ₍₅₎	6.4 ₍₃₎	2.95 ₍₃₎	16	F
Starks Creek ¹	2003	104 ₍₅₎	29 ₍₅₎	5.9 ₍₅₎	3.34 ₍₅₎	20	F
Starks Creek ¹	2021	95 ₍₅₎	30 ₍₅₎	5.1 ₍₅₎	3.65 ₍₅₎	20	F
BIOREF Score=5	---	>90	>22	<6.1	>3.24	20-16	Full
BIOREF Score=3	---	90-45	22-11	6.1-8.1	3.24-1.62	14-10	Partial
BIOREF Score=1	---	<45	<11	>8.1	<1.62	8-4	Non

MSCI Scoring Table (in light gray) developed from BIOREF streams ($n = 40$). TR = Taxa Richness; EPTT = Ephemeroptera, Plecoptera, Trichoptera Taxa; BI = Biotic Index; SDI = Shannon Diversity Index; Individual metric scores in ().

¹ = CANDREF Stream; ² = BIOREF Stream

Appendix B

Invertebrate Database Bench Sheet Report Fall 2020 and Spring 2021

Lindley Creek, Little Lindley Creek, Brush Creek, Macks Creek,
North Dry Sac River, Saline Creek, and Starks Creek.

Grouped by Season and Station

Bench Sheet Report, Fall 2020

Lindley Creek 1436_19.5, Dallas County			
Date 9/22/2020			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina			1
AMPHIPODA			
Gammarus	1	2	
Hyaella azteca			57
ARHYNCHOBDSELLIDA			
Erpobdellidae		*	
BASOMMATOPHORA			
Ancylidae	7	13	5
Menetus			3
Physella	1		7
BRANCHIOBDSELLIDA			
Branchiobdellida			
COLEOPTERA			
Ancyronyx variegatus			2
Berosus			2
Dubiraphia		1	40
Ectopria nervosa	3	2	
Helichus basalis			3
Macronychus glabratus			3
Psephenus herricki	50	5	1
Scirtidae			13
Stenelmis	33	9	3
DECAPODA			
Faxonius luteus	*	4	*
Faxonius virilis		*	
DIPTERA			
Ablabesmyia		4	1
Anopheles			2
Chironomidae			
Cladotanytarsus	1	1	
Corynoneura		1	
Cricotopus bicinctus			1
Cricotopus/Orthocladius	3		6
Dicrotendipes		2	2

Lindley Creek 1436_19.5, Dallas County			
Forcipomyiinae	4	1	4
Hemerodromia	2		
Hexatoma	7		
Labrundinia			6
Microtendipes	1	2	
Paratanytarsus		3	5
Paratendipes			1
Pentaneura	1		
Phaenopsectra			1
Polypedilum flavum	110		1
Polypedilum illinoense grp	1	1	7
Rheotanytarsus	11		3
Simulium	1		
Stempellinella	2	1	
Stenochironomus	1	2	
Stictochironomus		3	
Tanytarsus	19	1	8
Thienemanniella	2		
Thienemannimyia grp	15		3
Xenochironomus			1
EPHEMEROPTERA			
Acerpenna	54	2	
Baetis	101		
Caenis anceps	2	69	
Caenis latipennis	4	12	3
Isonychia bicolor	2		
Leptophlebiidae	5	11	1
Procladius	1	3	1
Stenacron	1	31	
Stenonema femoratum	18	112	
Stenonema mediopunctatum	2		
Tricorythodes	9		1
HEMIPTERA			
Belostoma			*
Rhagovelia	1		
LUMBRICINA			
Lumbricina	2	*	
MEGALOPTERA			
Corydalus	2		*

Lindley Creek 1436_19.5, Dallas County			
NEOTAENIOGLOSSA			
Elimia		1	6
ODONATA			
Argia	2	5	8
Boyeria			*
Calopteryx			2
Enallagma			51
Stylogomphus albistylus			1
PLECOPTERA			
Perlidae	27	1	
RHYNCHOBDELLIDA			
Glossiphoniidae		1	
TRICHOPTERA			
Cheumatopsyche	141		3
Chimarra	24		
Triaenodes			6
TRICLADIDA			
Planariidae	11		2
TUBIFICIDA			
Branchiura sowerbyi		2	
Limnodrilus hoffmeisteri		1	
Tubificinae	3	9	2
VENEROIDA			
Corbicula	*		*

Lindley Creek 1436_20.9, Dallas County			
Date 9/22/2020			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	4		
AMPHIPODA			
Gammarus	1		
Hyaella azteca	1	2	105
ARHYNCHOBDELLIDA			
Erpobdellidae	*	1	
BASOMMATOPHORA			
Ancylidae	3	2	
Helisoma	*		
Menetus			2

Lindley Creek 1436_20.9, Dallas County			
Physella	2	1	19
COLEOPTERA			
Berosus	10	6	2
Dubiraphia		1	10
Ectopria nervosa	1	8	
Helichus basalis	1		
Psephenus herricki		2	
Scirtidae			11
Stenelmis	52	6	4
DECAPODA			
Faxonius luteus		1	
Faxonius virilis	1		*
DIPTERA			
Ablabesmyia	18	9	1
Anopheles			2
Chironomidae			
Chironomus	17	9	
Cladotanytarsus	1		
Corynoneura	1		
Cricotopus/Orthocladius	9		
Cryptochironomus	3		
Cryptotendipes	3	1	
Dasyheleinae		1	
Dicrotendipes	42	31	1
Dixella			1
Glyptotendipes		1	2
Hexatoma	6		
Kiefferulus		1	
Labrundinia	3		
Microtendipes	12		
Nanocladius	3		
Natarsia			1
Paratanytarsus	1		4
Paratendipes	33	2	
Pentaneura	1		
Phaenopsectra	2		1
Polypedilum flavum	6		
Polypedilum illinoense grp	3		8
Polypedilum scalaenum grp	6		

Lindley Creek 1436_20.9, Dallas County			
Procladius		2	
Pseudochironomus		1	
Rheotanytarsus	3		
Stempellinella	3		
Stenochironomus		1	
Stictochironomus		5	
Tanytarsus	85	4	2
Thienemanniella	1		
Thienemannimyia grp	26		1
Xenochironomus			12
EPHEMEROPTERA			
Acerpenna	8		
Baetis	2		
Caenis latipennis	94	57	3
Leptophlebiidae	12	20	
Procladius		1	1
Stenacron	7	4	2
Stenonema femoratum	11	50	3
Tricorythodes	11	1	
HEMIPTERA			
Corixidae		1	
Gerridae	1		
Neoplea			2
Rheumatobates			3
Veliidae		1	
LUMBRICINA			
Lumbricina	*	*	
MEGALOPTERA			
Corydalus			*
Sialis		*	
NEOTAENIOGLOSSA			
Elimia	*		*
NEUROPTERA			
Climacia			1
ODONATA			
Argia	7	*	4
Enallagma	1		97
Macromia			*
PLECOPTERA			
Perlidae	3		

Lindley Creek 1436_20.9, Dallas County			
TRICHOPTERA			
Oecetis			3
Triatodes			5
TRICLADIDA			
Planariidae	73		2
TUBIFICIDA			
Branchiura sowerbyi		4	
Tubificinae	2	2	
VENEROIDA			
Corbicula	2	1	1

Little Lindley Creek 1438_1.2, Dallas County			
Date 9/22/2020			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina		1	
AMPHIPODA			
Crangonyx			1
Hyaella azteca	9	19	35
ARHYNCHOBDELLIDA			
Erpobdellidae	*		
BASOMMATOPHORA			
Ancylidae		1	5
Helisoma	*		1
Menetus	1	2	7
Physella	3	6	31
COLEOPTERA			
Berosus	2	14	5
Dubiraphia		1	7
Ectopria nervosa	3	14	5
Psephenus herricki	44		
Scirtidae			1
Stenelmis	30	2	2
DECAPODA			
Faxonius luteus	*		
Faxonius virilis			*
DIPTERA			
Ablabesmyia		9	4
Ceratopogoninae		2	1

Little Lindley Creek 1438_1.2, Dallas County			
Chironomidae	3	2	
Chironomus		1	
Corynoneura	5		
Cryptochironomus	1	2	
Dicranomyia	1		
Dicrotendipes		1	4
Forcipomyiinae	2		1
Labrundinia	2	1	7
Nanocladius			2
Nilothauma			1
Parachironomus			1
Paratanytarsus			1
Polypedilum flavum	181		2
Polypedilum illinoense grp	1		1
Polypedilum scalaenum grp		2	
Polypedilum tritum			1
Procladius		1	
Pseudochironomus		1	
Rheotanytarsus	3		
Stempellinella	15	15	2
Tanytarsus	7	4	7
Thienemanniella	3		
Thienemannimyia grp	16	1	
Tipula	*		
EPHEMEROPTERA			
Baetis	43	1	
Caenis latipennis	9	108	18
Hexagenia limbata		*	
Tricorythodes	3	9	
HEMIPTERA			
Microvelia	4		
Ranatra fusca			1
Trepobates			1
LUMBRICINA			
Lumbricina	1	*	1
NEOTAENIOGLOSSA			
Elimia	30	22	24
ODONATA			
Argia	9	1	7
Basiaeschna janata			1

Little Lindley Creek 1438_1.2, Dallas County			
Enallagma		2	79
Epitheca (Epicordulia)			*
Hagenius brevistylus			*
Macromia		*	2
TRICHOPTERA			
Cheumatopsyche	62		2
Chimarra	45		
Hydropsyche	1		
Hydroptila	5	2	6
Oecetis			1
TRICLADIDA			
Planariidae	184	7	3
TUBIFICIDA			
Tubificinae	5		3
VENEROIDA			
Corbicula	7	9	1
Pisidiidae		1	

Little Lindley Creek 1438_2.5, Dallas County			
Date 9/23/2020			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
AMPHIPODA			
Crangonyx	*	5	50
Hyaella azteca	1	2	126
ARHYNCHOBDELLIDA			
Erpobdellidae		4	
BASOMMATOPHORA			
Ancylidae	2	13	1
Gyraulus		2	2
Helisoma			1
Menetus		1	2
Physella		1	8
COLEOPTERA			
Berosus	1	2	
Dubiraphia		1	1
Ectopria nervosa	7	18	2
Psephenus herricki	123	5	1
Stenelmis	27	23	6
DECAPODA			

Little Lindley Creek 1438_2.5, Dallas County			
Faxonius luteus	*	*	*
DIPTERA			
Ablabesmyia	1	9	1
Chironomidae			
Cricotopus/Orthocladius	2		
Culicidae			1
Dicrotendipes	3	31	4
Forcipomyiinae	1		
Hemerodromia	1		
Labrundinia			1
Paratanytarsus	3	2	4
Phaenopsectra		2	1
Polypedilum flavum	33	1	
Polypedilum illinoense grp	2		
Polypedilum scalaenum grp		1	
Pseudochironomus		1	
Rheotanytarsus	20		
Stempellinella	1	6	1
Stictochironomus		3	
Tanytarsus	11	16	2
Thienemanniella	2	5	
Thienemannimyia grp	8		
EPHEMEROPTERA			
Baetis	51	1	1
Caenis latipennis		53	4
Leptophlebiidae	2		
Stenonema femoratum		35	
HEMIPTERA			
Microvelia	1		1
Rhagovelia	6		
LUMBRICINA			
Lumbricina	2	*	
LUMBRICULIDA			
Lumbriculidae		1	
NEOTAENIOGLOSSA			
Elimia	1	7	8
ODONATA			
Argia	19	23	15
Enallagma			18

Little Lindley Creek 1438_2.5, Dallas County			
Hetaerina		1	
RHYNCHOBDELLIDA			
Piscicolidae			2
TRICHOPTERA			
Cheumatopsyche	116	1	
Chimarra	133	*	
Hydropsyche	11		
Hydroptila			1
Oecetis			2
Plectrocnemia	1	1	
Triaenodes		1	20
TRICLADIDA			
Planariidae	74	1	7
TUBIFICIDA			
Branchiura sowerbyi		1	
Enchytraeidae		1	
Tubificinae		12	1
VENEROIDA			
Corbicula		4	1

Little Lindley Creek 1438_2.5, Dallas County			
Date 9/23/.2020			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
AMPHIPODA			
Crangonyx	2	20	19
Hyaella azteca	1	4	180
ARHYNCHOBDELLIDA			
Erpobdellidae		*	
BASOMMATOPHORA			
Ancylidae		4	1
Gyraulid		2	1
Helisoma			2
Menetus		1	
Physella	1	1	2
COLEOPTERA			
Berosus		3	
Dubiraphia			3
Dytiscidae	1		
Ectopria nervosa	1	9	2

Little Lindley Creek 1438_2.5, Dallas County			
Psephenus herricki	52	9	
Stenelmis	21	30	2
DECAPODA			
Faxonius luteus	*	*	
Faxonius virilis			*
DIPTERA			
Ablabesmyia	1	11	
Anopheles		1	
Chironomidae	3	1	
Corynoneura	2		
Cricotopus/Orthocladius	1	3	
Dicrotendipes	7	29	1
Ephydriidae	1		
Geranomyia	1		
Hemerodromia	3		
Labrundinia			5
Microtendipes		2	
Paratanytarsus	3	2	2
Phaenopsectra	1	2	
Polypedilum flavum	34		1
Polypedilum illinoense grp	12		
Polypedilum scalaenum grp		1	
Procladius		1	
Pseudochironomus		1	
Rheotanytarsus	24	1	
Simulium	2		
Stempellinella	3	13	3
Stenochironomus		1	
Tanytarsus	18	19	1
Thienemanniella	7	2	1
Thienemannimyia grp	9	2	
Tipula		*	
EPHEMEROPTERA			
Baetis	53		
Caenis latipennis		21	
Neocloeon		1	
Stenacron		1	
Stenonema femoratum		21	1
HEMIPTERA			
Rhagovelia	1		

Little Lindley Creek 1438_2.5, Dallas County			
LUMBRICINA			
Lumbricina	*	*	
LUMBRICULIDA			
Lumbriculidae		1	
NEOTAENIOGLOSSA			
Elimia	*	4	3
ODONATA			
Argia	17	27	12
Calopteryx	1		
Enallagma			19
Perithemis			1
TRICHOPTERA			
Cheumatopsyche	128		
Chimarra	165		
Oecetis	2		8
Plectrocnemia	3		
Trienodes			13
TRICLADIDA			
Planariidae	91	3	1
TUBIFICIDA			
Enchytraeidae			1
Tubificinae		18	4
VENEROIDA			
Pisidiidae		4	

Brush Creek 1370_2.9, St. Clair County			
Date 9/15/2020			
* - large rare			
ORDER: Observed Taxa	CS	N F	R M
"HYDRACARINA"			
Acarina	12	5	24
AMPHIPODA			
Hyaella azteca		6	7
BASOMMATOPHORA			
Ancylidae	4	5	4
Helisoma			*
Menetus			1
Physella			1
COLEOPTERA			
Ancyronyx variegatus		1	1

Brush Creek 1370_2.9, St. Clair County			
Berosus		4	
Dubiraphia	1	11	119
Ectopria nervosa		1	
Macronychus glabratus	1		8
Psephenus herricki	10	2	
Stenelmis	18		4
DECAPODA			
Faxonius luteus		*	
DIPTERA			
Ablabesmyia	2	10	4
Ceratopogoninae		5	
Chironomidae		3	1
Cladopelma		2	
Cladotanytarsus	5	5	
Clinotanypus		1	1
Corynoneura			2
Cricotopus bicinctus	3		1
Cricotopus/Orthocladius	11	1	2
Cryptochironomus		1	
Cryptotendipes		5	
Dicrotendipes	4	3	
Ephydriidae			1
Hemerodromia	1		
Hexatoma	1		
Labrundinia			6
Microtendipes			1
Nanocladius	2		1
Paralauterborniella		3	
Paratanytarsus			5
Polypedilum flavum	3		
Polypedilum illinoense grp			4
Procladius		1	
Pseudochironomus		1	
Rheocricotopus			2
Rheotanytarsus	2		
Simulium	2		1
Stempellinella	6	10	1
Stenochironomus	2		2
Tabanus		1	
Tanytarsus	5	15	18

Brush Creek 1370_2.9, St. Clair County			
Thienemanniella	5		
Thienemannimyia grp			2
Tribelos		1	
EPHEMEROPTERA			
Anthopotamus	3	3	
Baetis	25	2	
Caenis anceps	17	71	1
Choroterpes	3	6	1
Ephemera simulans	*	1	
Hexagenia limbata		1	
Isonychia bicolor	18		
Leucrocuta	29		
Procloeon		7	
Stenacron	1	1	5
Stenonema femoratum	1	31	3
Stenonema pulchellum	90	3	4
Tricorythodes	15 5	5	31
HEMIPTERA			
Corixidae			1
Metrobates			2
Rhagovelia	1		
Trepobates			2
LEPIDOPTERA			
Petrophila		2	
LUMBRICINA			
Lumbricina		1	
MEGALOPTERA			
Corydalus	6		1
Sialis		1	
NEOTAENIOGLOSSA			
Elimia	25	3	5
Hydrobiidae		6	
ODONATA			
Argia			2
Calopteryx			3
Enallagma	5	1	23
Gomphidae	1		
Macromia	*		*
PLECOPTERA			
Perlesta	11		

Brush Creek 1370_2.9, St. Clair County			
TRICHOPTERA			
Cernotina		2	
Cheumatopsyche	2		
Chimarra	8		
Helicopsyche	56	1	
Mystacides	1	1	
Oecetis	6	1	9
Triaenodes		2	12
TRICLADIDA			
Planariidae		2	
TUBIFICIDA			
Branchiura sowerbyi			1
Tubificinae		4	
VENEROIDA			
Corbicula	52	15	
Pisidiidae			1

Macks Creek 1200_2.4, Camden County			
Date 9/15/2020			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	34	12	
AMPHIPODA			
Allocrangonyx	1		
Hyalella azteca			38
BASOMMATOPHORA			
Ancylidae	3	3	
Gyraulus	1	1	
Physella	19	3	6
COLEOPTERA			
Dubiraphia		3	9
Ectopria nervosa			1
Enochrus			2
Helichus basalis			2
Helichus lithophilus			1
Optioservus sandersoni	1		2
Psephenus herricki	4		
Scirtidae			8
Stenelmis	33	86	5
Tropisternus			1

Macks Creek 1200_2.4, Camden County			
DECAPODA			
Faxonius luteus	*		*
DIPTERA			
Ablabesmyia		9	9
Ceratopogoninae	3	6	4
Chironomidae		1	
Chironomus		3	
Cladotanytarsus	2	25	1
Cricotopus bicinctus			1
Cricotopus/Orthocladius	11	1	1
Cryptochironomus	1		
Cryptotendipes		1	
Culicidae			
Dicrotendipes	1	16	4
Dixella			
Forcipomyiinae			1
Hemerodromia	2		
Hexatoma	9	1	
Micropsectra		1	1
Microtendipes	17	2	
Natarsia			1
Nilothauma		1	
Parametriocnemus	10		
Paratanytarsus		1	7
Phaenopsectra	1	1	2
Polypedilum flavum	26		
Polypedilum illinoense grp			1
Polypedilum scalaenum grp	3		
Pseudochironomus	1		2
Pseudolimnophila			
Rheocricotopus	3		
Rheotanytarsus	7		1
Stempellina		1	
Stempellinella		3	
Tanytarsus		26	3
Thienemanniella	2	1	
Thienemannimyia grp	6	4	11
EPHEMEROPTERA			
Acerpenna	99		
Baetis	29		4

Macks Creek 1200_2.4, Camden County			
Baetisca lacustris	1		
Caenis anceps	85	22	1
Caenis latipennis	11	27	5
Choroterpes		*	
Heptageniidae	1		
Isonychia bicolor	4		
Leptophlebiidae	2	20	2
Leucrocota	7		
Plauditus	3		
Procloeon		3	3
Stenonema femoratum		12	2
Stenonema mediopunctatum	11		
Stenonema pulchellum	10		
Tricorythodes	97	15	101
HEMIPTERA			
Microvelia			1
Neoplea			1
Rhagovelia	1		11
ISOPODA			
Caecidotea (Blind & Unpigmented)	1		
LUMBRICINA			
Lumbricina	2		
LUMBRICULIDA			
Lumbriculidae			3
MEGALOPTERA			
Corydalus	3		
Sialis		*	
ODONATA			
Argia	2	3	13
Basiaeschna janata			2
Boyeria			2
Calopteryx			10
Enallagma			22
Gomphidae	5	3	
Hagenius brevistylus	1		
Hetaerina			2
Ischnura			4
Macromia			2
Stylogomphus albistylus		1	
PLECOPTERA			

Macks Creek 1200_2.4, Camden County			
Agnetina capitata	5		
Leuctra	2	5	
Neoperla	33	10	1
TRICHOPTERA			
Cheumatopsyche	52	1	
Chimarra	5	1	
Dibusa angata	1		
Helicopsyche	4		
Hydropsyche morosa grp	1		
Hydroptila	13	2	6
Limnephilidae			*
Marilia	3	2	
Molanna	1		
Oecetis	5	3	11
Oxyethira			6
Ptilostomis		1	
Triaenodes	1	2	17
TUBIFICIDA			
Enchytraeidae	1		
Tubificinae			1

North Dry Sac River 1393_5.2, Greene County			
Date 9/23/2020			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina		5	
AMPHIPODA			
Hyalella azteca		1	28
BASOMMATOPHORA			
Ancylidae	1		1
Menetus			9
Physella			8
COLEOPTERA			
Dubiraphia		4	8
Ectopria nervosa	1	17	1
Microcyloepus pusillus	2		1
Psephenus herricki	248	130	9
Stenelmis	49	18	17
DECAPODA			
Faxonius luteus		*	

North Dry Sac River 1393_5.2, Greene County			
Faxonius neglectus	*		
DIPTERA			
Ablabesmyia	1	6	
Anopheles			1
Ceratopogoninae	1	1	
Chironomidae		1	1
Corynoneura		1	3
Cricotopus/Orthocladius			1
Cryptochironomus			1
Dicrotendipes		1	
Dixella			4
Forcipomyiinae	3		
Hexatoma	*	*	
Labrundinia			2
Parametriocnemus	1		
Paratendipes		6	
Polypedilum flavum	6		1
Polypedilum illinoense grp			3
Polypedilum scalaenum grp		2	
Rheocricotopus			3
Rheotanytarsus			7
Simulium	2		
Stempellinella	2	4	5
Tabanus	2	*	
Tanytarsus	6	1	4
Thienemanniella	2		
Thienemannimyia grp	2	2	2
Tribelos		13	
EPHEMEROPTERA			
Acentrella	3		
Acerpenna	11		1
Anthopotamus		1	
Baetis	8		
Caenis anceps	5	10	
Caenis latipennis		31	9
Isonychia bicolor	3		
Leptophlebiidae	5	100	15
Leucrocuta	36		
Procladius			1

North Dry Sac River 1393_5.2, Greene County			
Stenacron		6	
Stenonema femoratum		22	
Stenonema mediopunctatum	3		
Stenonema pulchellum	75	1	
Stenonema terminatum	2		
Tricorythodes		2	
HEMIPTERA			
Belostoma			*
Microvelia	2		
Rhagovelia	1		
LUMBRICINA			
Lumbricina	2	*	
MEGALOPTERA			
Corydalus	*		*
Nigronia serricornis			*
NEOTAENIOGLOSSA			
Elimia	73	12	81
ODONATA			
Argia	18	10	
Basiaeschna janata			*
Boyeria			*
Calopteryx			2
Enallagma			7
Gomphidae	3	1	
Hagenius brevistylus			*
PLECOPTERA			
Acrocnemura	5	1	
Agnetina capitata	18	1	
TRICHOPTERA			
Cheumatopsyche	5		
Chimarra	2		
Helicopsyche	30		17
Hydroptila	1		1
Oecetis		1	8
Plectrocnemia	1	3	
Triaenodes			12
TRICLADIDA			
Planariidae	10		
VENEROIDA			
Pisidiidae		1	

Saline Creek 1048_2.4, Miller County			
Date 9/16/2020			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	10	6	
AMPHIPODA			
Allocrangonyx	8	7	
Crangonyx	1		*
ARHYNCHOBELLIDA			
Erpobdellidae	*		
BASOMMATOPHORA			
Ancylidae	5	3	11
Menetus	2		1
Physella	5	5	8
COLEOPTERA			
Ancyronyx variegatus			8
Berosus		1	1
Dubiraphia		1	10
Helichus basalis		1	
Hydrophilus			1
Macronychus glabratus			9
Microcylloepus pusillus			8
Ochthebius	1		
Optioservus sandersoni	1		
Paracymus			1
Psephenus herricki	12		
Scirtidae			7
Stenelmis	20	16	4
Tropisternus			*
DECAPODA			
Faxonius luteus	2		1
Faxonius virilis			1
DIPTERA			
Ablabesmyia		9	1
Ceratopogoninae	4	1	
Chironomus		7	
Chrysops			1
Cladotanytarsus	1	3	
Corynoneura			1

Saline Creek 1048_2.4, Miller County			
Cricotopus/Orthocladius	1		
Cryptochironomus	5	8	2
Dicrotendipes	2	2	1
Diptera			1
Dixella			1
Empididae		1	
Forcipomyiinae			1
Hemerodromia	4		2
Hexatoma	9	2	
Labrundinia		1	2
Micropsectra			1
Microtendipes	21		
Natarsia		2	
Paracladopelma		5	
Parametriocnemus	8		1
Paratanytarsus			5
Paratendipes	1		
Polypedilum flavum	11		3
Polypedilum scalaenum grp		1	
Rheocricotopus	2		
Rheotanytarsus	13		42
Simulium			3
Stempellinella		4	
Stictochironomus		10	
Tabanus	1		
Tanytarsus		2	6
Thienemanniella	1	1	
Thienemannimyia grp	11	9	4
EPHEMEROPTERA			
Acerpenna	22		
Baetis	5		
Caenis anceps	96	58	1
Caenis latipennis	56	103	67
Choroterpes	2	5	
Isonychia bicolor	3		3
Leucrocuta	9	3	
Procloeon	1	6	2
Stenacron	2		1
Stenonema femoratum	7	16	1
Stenonema modestum	73		1

Saline Creek 1048_2.4, Miller County			
Stenonema pulchellum	7		4
Tricorythodes	49	8	2
HEMIPTERA			
Microvelia			20
Rheumatobates			2
ISOPODA			
Caecidotea (Blind & Unpigmented)		4	
Lirceus	2		
LUMBRICINA			
Lumbricina	8	4	
MEGALOPTERA			
Corydalus	5		*
NEOTAENIOGLOSSA			
Elimia	*	2	*
ODONATA			
Argia	1		6
Basiaeschna janata			*
Boyeria			*
Calopteryx			7
Dromogomphus			2
Enallagma			25
Gomphidae	2	3	
Hagenius brevistylus		1	
Macromia			*
PLECOPTERA			
Neoperla	3		
Perlinella ephyre	4	1	
Zealeuctra	2	1	
RHYNCHOBDELLIDA			
Glossiphoniidae		1	
TRICHOPTERA			
Cheumatopsyche	64		6
Chimarra	6		2
Helicopsyche	4		
Hydroptila			2
Nectopsyche			1
Oecetis			2
Phryganeidae		1	3
Plectrocnemia		1	
Polycentropus			1

Saline Creek 1048_2.4, Miller County			
Triaenodes			6
TRICLADIDA			
Planariidae	1		
TUBIFICIDA			
Branchiura sowerbyi			1
Tubificinae	1	5	9
VENEROIDA			
Corbicula	8	2	

Starks Creek 1192_0.6, Hickory County			
Date 9/15/2020			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina		5	
AMPHIPODA			
Allocrangonyx		3	
Gammarus			1
Hyaella azteca			6
BASOMMATOPHORA			
Menetus			2
COLEOPTERA			
Dubiraphia			7
Ectopria nervosa		1	
Helichus fastigiatus			3
Macronychus glabratus	1		
Psephenus herricki	3		
Scirtidae			7
Stenelmis	6	15	1
DECAPODA			
Faxonius luteus	1		2
Faxonius virilis			1
DIPTERA			
Ablabesmyia		7	5
Anopheles			1
Ceratopogoninae	2	7	
Chironomidae	6	1	1
Chironomus		6	21
Cladotanytarsus	8	65	1
Corynoneura		1	1
Cricotopus/Orthocladius	5	5	

Starks Creek 1192_0.6, Hickory County			
Cryptochironomus	1	2	
Dicrotendipes	1	12	3
Dixella			7
Ephydriidae	*		
Hemerodromia	6		
Hexatoma	29	9	
Labrundinia		1	
Microtendipes	29	38	
Parametriocnemus	3		
Paratanytarsus			3
Paratendipes			1
Pentaneura		1	
Phaenopsectra			1
Polypedilum flavum	67	1	21
Polypedilum halterale grp		1	
Polypedilum illinoense grp			11
Polypedilum scalaenum grp		4	
Procladius			2
Pseudochironomus		1	
Rheocricotopus			1
Rheotanytarsus	14		10
Saetheria		3	
Simulium	2		
Stempellinella		2	1
Stenochironomus		1	
Tabanus	*		
Tanytarsus	4	20	8
Thienemanniella	8	3	
Thienemannimyia grp	2	1	5
EPHEMEROPTERA			
Acentrella	1		
Acerpenna	11		16
Baetis	201		17
Caenis anceps	18	6	2
Caenis latipennis		1	14
Choroterpes		2	
Isonychia bicolor	20		10
Leptophlebiidae		2	1
Plauditus	1		
Procloeon		19	

Starks Creek 1192_0.6, Hickory County			
Stenonema femoratum		7	3
Stenonema mediopunctatum	3		
Stenonema pulchellum	11	1	1
Tricorythodes	7	3	1
GORDIOIDEA			
Gordiidae	*		
HEMIPTERA			
Gerridae			1
Hydrometra			1
Mesovelgia			1
Rhagovelia	2		1
ISOPODA			
Caecidotea (Blind & Unpigmented)		2	
MEGALOPTERA			
Corydalus	11		4
NEOTAENIOGLOSSA			
Elimia	1		
ODONATA			
Argia		2	5
Calopteryx			13
Enallagma			24
Gomphidae	3	2	
Hagenius brevistylus		1	
PLECOPTERA			
Leuctridae			1
Neoperla	31	4	
TRICHOPTERA			
Cheumatopsyche	35		
Chimarra	5	1	
Helicopsyche	1		
Oecetis	1	1	14
Phryganeidae		1	
Triaenodes			15
TUBIFICIDA			
Tubificinae	1		

Bench Sheet Report, Spring 2021

Lindley Creek 1436_19.5, Dallas County			
Date 4/15/2021			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA "			
Acarina		6	
AMPHIPODA			
Crangonyx	53	18	100
Hyalella azteca		2	12
ARHYNCHOBDELLIDA			
Erpobdellidae			1
BASOMMATOPHORA			
Ancylidae		4	3
Menetus			1
Physella		1	*
COLEOPTERA			
Berosus			1
Dubiraphia		1	6
Dytiscidae			1
Macronychus glabratus			1
Neoporus			2
Peltodytes		1	
Psephenus herricki	2	1	1
Stenelmis	96	3	1
DECAPODA			
Faxonius luteus			1
Faxonius neglectus	2		
Faxonius virilis			*
DIPTERA			
Ablabesmyia			1
Ceratopogoninae	7	1	1
Chironomidae	3	3	
Chironomus	8	47	6
Cladotanytarsus	3	1	1
Cricotopus/Orthocladius	54	13	14
Cryptochironomus		1	
Cryptotendipes		2	
Dicrotendipes	13	55	15
Diptera	2	1	
Eukiefferiella	59	2	3
Hemerodromia		1	

Lindley Creek 1436_19.5, Dallas County			
Hexatoma	2		
Hydrobaenus	17	18	4
Micropsectra	1		
Paratanytarsus	2	1	4
Paratendipes	2	1	1
Phaenopsectra		1	
Polypedilum flavum	21		
Polypedilum scalaenum grp	5	2	1
Rheotanytarsus			2
Simulium	4		1
Stenochironomus			1
Stictochironomus	44	243	6
Tanytarsus	3	1	3
Thienemannimyia grp	5		4
Tipula	1		
EPHEMEROPTERA			
Acentrella	3		
Caenis latipennis	15	22	31
Plauditus	57		3
Stenacron	7		
Stenonema femoratum	15	*	1
LUMBRICINA			
Lumbricina	3	*	
LUMBRICULIDA			
Lumbriculidae		1	
NEOTAENIOGLOSSA			
Elimia	3		1
Hydrobiidae			2
ODONATA			
Argia	2	1	3
Basiaeschna janata			*
Calopteryx			7
Corduliidae			1
Dromogomphus			1
Enallagma			24
Hetaerina			1
Libellula			*
Macromia			1
Nasiaeschna pentacantha			*
Somatochlora			*

Lindley Creek 1436_19.5, Dallas County			
PLECOPTERA			
Amphinemura	1		
Isoperla	3		
Neoperla	1		
Perlesta	36		
TRICHOPTERA			
Cheumatopsyche	*		
Oecetis			3
Polycentropodidae		1	
Trienodes			4
TRICLADIDA			
Planariidae	12		6
TUBIFICIDA			
Enchytraeidae	1		
Limnodrilus hoffmeisteri	4	3	2
Tubificinae	9	29	2
VENEROIDA			
Corbicula	2		*
Pisidiidae		1	*

Lindley Creek 1436_20.9, Dallas County			
Date 4/15/2021			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina		5	
AMPHIPODA			
Crangonyx	7	7	49
Hyaella azteca			29
ARHYNCHOBDELLIDA			
Erpobdellidae	*		
BASOMMATOPHORA			
Ancylidae		*	
Physella			*
COLEOPTERA			
Agabus			1
Berosus			1
Dubiraphia		1	1
Hydraena		1	
Psephenus herricki	1		

Lindley Creek 1436_20.9, Dallas County			
Stenelmis	113	4	4
DECAPODA			
Faxonius luteus	*		
Faxonius virilis			*
DIPTERA			
Ablabesmyia		2	
Ceratopogoninae	3	3	1
Chironomidae	2	2	4
Chironomus	5	57	8
Cladotanytarsus		1	
Cricotopus/Orthocladius	31	11	22
Cryptochironomus		1	
Dicrotendipes	2	6	34
Diplocladius	1		
Eukiefferiella	87	4	26
Glyptotendipes			3
Hemerodromia	1		
Hexatoma	5	*	
Hybomitra	*		
Hydrobaenus	1	9	17
Microtendipes	2	2	2
Paratanytarsus		1	8
Paratendipes	1		
Polypedilum flavum	14		1
Polypedilum halterale grp	2	4	
Simulium	1		4
Stempellinella			1
Stictochironomus	2	188	2
Tanytarsus		1	1
Thienemannimyia grp	1		5
Tipula	*		
EPHEMEROPTERA			
Acentrella	26		
Baetis	2		
Caenis latipennis	2	4	11
Plauditus	76		19
Siphonurus			1
Stenacron	2		
Stenonema femoratum	2	1	1
HEMIPTERA			

Lindley Creek 1436_20.9, Dallas County			
Corixidae		1	
Microvelia			1
LUMBRICINA			
Lumbricina	12		
LUMBRICULIDA			
Lumbriculidae	1		
NEOTAENIOGLOSSA			
Elimia	2		*
ODONATA			
Calopteryx			*
Dromogomphus			*
Enallagma			13
PLECOPTERA			
Alloperla	2		
Amphinemura	17		1
Isoperla	4		
Neoperla	4		
Perlesta	110		2
TRICHOPTERA			
Oecetis			1
Rhyacophila	2		
Triaenodes			*
TRICLADIDA			
Planariidae	8	*	1
TUBIFICIDA			
Branchiura sowerbyi	2		
Limnodrilus hoffmeisteri	4	3	2
Tubificinae	90	33	4
VENEROIDA			
Corbicula	*		
Pisidiidae	3		

Little Lindley Creek 1438_1.2, Dallas County			
Date 4/15/2021			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina		1	1
AMPHIPODA			
Crangonyx	17	6	9

Little Lindley Creek 1438_1.2, Dallas County			
ARHYNCHOBDELLIDA			
Erpobdellidae	2		
BASOMMATOPHORA			
Ancylidae	1		2
Physella		1	19
COLEOPTERA			
Ectopria nervosa	1		
Psephenus herricki	20		
Stenelmis	89	13	1
DECAPODA			
Faxonius luteus	*		
Faxonius virilis			1
DIPTERA			
Ablabesmyia	1		
Chironomidae	21	23	8
Chironomus	2	19	3
Clinocera	1		
Cricotopus/Orthocladius	38	3	7
Dicrotendipes	23	150	20
Diplocladius	2		
Diptera		1	
Eukiefferiella	204	6	
Hydrobaenus	1	2	
Paratanytarsus	1	1	
Paratendipes		2	2
Polypedilum flavum	72		
Polypedilum illinoense grp	3		
Polypedilum scalaenum grp	2	1	
Rheotanytarsus	1		1
Simulium	21		
Stictochironomus	1	74	1
Thienemanniella	3		3
Thienemannimyia grp	7		2
Tipula	*		
EPHEMEROPTERA			
Baetis	23		
Caenis latipennis	3	3	1
LUMBRICINA			
Lumbricina	1	1	

Little Lindley Creek 1438_1.2, Dallas County			
NEOTAENIOGLOSSA			
Elimia	23		164
ODONATA			
Argia	1		2
Calopteryx			1
Enallagma			13
Epitheca (Epicordulia)			*
PLECOPTERA			
Perlesta	2		
TRICHOPTERA			
Cheumatopsyche	1		
Hydroptila	4		
Plectrocnemia	*		
Triaenodes			14
TRICLADIDA			
Planariidae	29		3
TUBIFICIDA			
Aulodrilus			1
Branchiura sowerbyi		*	
Limnodrilus hoffmeisteri		2	1
Tubificinae	3	1	7
VENEROIDA			
Corbicula			1

Little Lindley Creek 1438_2.5, Dallas County			
Date 4/15/2021			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	2	2	
AMPHIPODA			
Crangonyx	6	6	11
ARHYNCHOBELLIDA			
Erpobdellidae	*	*	*
BASOMMATOPHORA			
Ancylidae		3	
Helisoma	*		*
Menetus			*
Physella	1	6	12

Little Lindley Creek 1438_2.5, Dallas County			
COLEOPTERA			
Berosus	*		
Ectopria nervosa			1
Psephenus herricki	1		
Stenelmis	23	2	1
DECAPODA			
Faxonius luteus		*	
DIPTERA			
Antocha			1
Chironomidae	13	10	8
Chironomus	5	29	4
Cricotopus bicinctus	2		3
Cricotopus/Orthocladius	44	8	25
Dicrotendipes	89	413	141
Diplocladius	2		
Diptera		3	
Eukiefferiella	409	17	204
Hydrobaenus	2		
Microtendipes		2	
Parametriocnemus	1		
Paratanytarsus	1	5	4
Paratendipes		3	
Polypedilum flavum	7	1	3
Polypedilum scalaenum grp	1		
Rheotanytarsus			2
Simulium	5	1	3
Stictochironomus	1	21	1
Tanytarsus	2	1	2
Thienemannimyia grp		1	2
Tipula	1	*	*
EPHEMEROPTERA			
Baetis	13		3
Caenis latipennis	1	4	1
Leptophlebiidae	1		
Stenonema femoratum	*		
LUMBRICINA			
Lumbricina	*	*	
NEOTAENIOGLOSSA			
Elimia	2	3	4
ODONATA			

Little Lindley Creek 1438_2.5, Dallas County			
Argia	1		*
Calopteryx			*
Enallagma			1
Ischnura			*
PLECOPTERA			
Perlesta	1		
TRICHOPTERA			
Cheumatopsyche	*		2
Chimarra	*		
Hydroptila	1	1	
Triaenodes		2	3
TRICLADIDA			
Planariidae	9	4	4
TUBIFICIDA			
Limnodrilus hoffmeisteri		7	1
Tubificinae		9	
VENEROIDA			
Corbicula		1	

Brush Creek 1370_2.9, St. Clair County			
Date 3/30/2021			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	3	13	12
AMPHIPODA			
Crangonyx	2	1	12
Hyaella azteca		3	30
COLEOPTERA			
Berosus			4
Dubiraphia	4	10	15
Dytiscidae		2	
Gyretes			*
Helichus basalis	1		
Helichus lithophilus			2
Macronychus glabratus			2
Optioservus sandersoni	1		
Psephenus herricki	5		*
Scirtidae			4
Stenelmis	56	9	4

Brush Creek 1370_2.9, St. Clair County			
DECAPODA			
Faxonius virilis			*
DIPTERA			
Ablabesmyia		8	8
Ceratopogonidae	1	8	1
Chironomidae	3	1	1
Cladotanytarsus		9	
Clinocera	12	3	
Cricotopus/Orthocladius	19	12	11
Cryptochironomus		5	1
Cryptotendipes		6	
Dasyheleinae		2	
Dicrotendipes		6	
Diplocladius		2	1
Diptera		12	1
Eukiefferiella	122	12	20
Hemerodromia	3		
Hydrobaenus		21	1
Labrundinia			5
Nanocladius		1	
Nilotanytus			1
Nilothauma		2	
Ormosia		1	
Orthocladius (Euorthocladius)	2		2
Parakiefferiella		1	
Paralauterborniella		7	1
Parametriocnemus	1	1	
Paratanytarsus		2	3
Paratendipes		3	
Phaenopsectra		2	
Polypedilum aviceps	1	1	
Polypedilum fallax grp	1		
Polypedilum flavum	9		1
Polypedilum illinoense grp		1	5
Prosimulium	10		1
Rheocricotopus	1	2	
Simulium	68	1	1
Stempellinella		1	3
Sympotthastia	3	2	3
Tabanus	3	*	

Brush Creek 1370_2.9, St. Clair County			
Tanytarsus	2	25	13
Telopelopia	1	2	
Thienemannimyia grp	3	5	3
Tipula	1		
EPHEMEROPTERA			
Acerpenna		3	1
Anthopotamus	1		*
Caenis latipennis	86	47	57
Ephemera simulans			*
Isonychia bicolor	3		
Leptophlebia			2
Paraleptophlebia	2		9
Plautidus	52	1	7
Stenacron	11	1	2
Stenonema femoratum	12		1
Stenonema pulchellum	36		1
Stenonema terminatum	6		2
Tricorythodes	37	1	4
LEPIDOPTERA			
Petrophila	2		
LUMBRICINA			
Lumbricina	1	1	
MEGALOPTERA			
Corydalus	*		
NEOTAENIOGLOSSA			
Elimia	17	2	
ODONATA			
Basiaeschna janata			*
Enallagma			4
Gomphidae			*
PLECOPTERA			
Agnetina flavescens	8		
Amphinemura	52	3	9
Chloroperlidae		1	
Isoperla	17	*	1
Perlesta	51	14	19
TRICHOPTERA			
Agapetus	1	3	
Cernotina			1
Chimarra	6		

Brush Creek 1370_2.9, St. Clair County			
Helicopsyche	11		1
Hydroptila	2		
Ironoquia			*
Mystacides			1
Nectopsyche		3	3
Oecetis			1
Platycentropus			*
Ptilostomis			2
Pycnopsyche			*
Triaenodes			3
TRICLADIDA			
Planariidae	2		1
TUBIFICIDA			
Branchiura sowerbyi		2	
Enchytraeidae			3
Limnodrilus claparedianus		1	
Limnodrilus hoffmeisteri		3	
Tubificinae	3	16	2
VENEROIDA			
Corbicula	4	2	2

Macks Creek 1200_2.4, Camden County			
Date 3/30/2021			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	33	22	1
AMPHIPODA			
Allocrenonyx	4	3	
Hyaella azteca			5
COLEOPTERA			
Dubiraphia		3	
Ectopria nervosa		1	
Heterosternuta		1	
Hydraena		1	
Lutrochus	2		
Stenelmis	15	35	
DIPTERA			
Ablabesmyia		2	
Ceratopogoninae	59	9	
Cladotanytarsus	1	4	

Macks Creek 1200_2.4, Camden County			
Clinocera	13		
Corynoneura	1	1	
Cricotopus/Orthocladius	10	3	7
Eukiefferiella	32		2
Hemerodromia	2		
Hexatoma	35	5	
Hydrobaenus		2	
Labrundinia		1	
Limoniidae			1
Micropsectra			1
Microtendipes	3	2	
Orthocladius (Euorthocladius)			1
Parametriocnemus	22	6	
Paratanytarsus			3
Polypedilum aviceps	7		
Polypedilum flavum	11		
Potthastia		1	
Prosimulium			1
Pseudochironomus		1	
Rheocricotopus	4	1	3
Robackia	1	1	
Simulium	2		3
Sympotthastia	26	1	14
Tabanus	*	*	
Tanytarsus	1	2	
Thienemanniella	2		
Thienemannimyia grp		27	5
EPHEMEROPTERA			
Acentrella	9		
Acerpenna	5		6
Caenis anceps	9	19	4
Caenis latipennis	13	81	176
Callibaetis			2
Eurylophella		1	3
Isonychia bicolor	2		
Leucrocuta	4	6	
Plauditus	51		5
Stenacron		1	
Stenonema femoratum	6	3	4

Macks Creek 1200_2.4, Camden County			
Stenonema mediopunctatum	3		
Stenonema pulchellum	4	1	
Tricorythodes	1		2
GORDIOIDEA			
Gordiidae	1		
HEMIPTERA			
Microvelia			4
ISOPODA			
Caecidotea (Blind & Unpigmented)		5	
Lirceus			3
LUMBRICINA			
Lumbricina	1		
MEGALOPTERA			
Corydalus	1		
NEOTAENIOGLOSSA			
Elimia	1		
ODONATA			
Boyeria			1
Calopteryx			4
Enallagma			1
Gomphidae		4	1
Helocordulia			*
Macromia			*
Stylogomphus sigmastylus		1	
PLECOPTERA			
Acroneuria	*		
Alloperla	18	2	
Amphinemura	33	1	2
Clioperla clio			1
Isoperla	16	1	
Leuctridae	6	6	1
Neoperla	60	22	
Perlesta	10	4	13
Perlinella ephyre	5	2	
TRICHOPTERA			
Agapetus	1		
Cernotina			*
Cheumatopsyche	9	*	4
Chimarra	5	1	

Macks Creek 1200_2.4, Camden County			
Helicopsyche	1		
Hydroptila		1	4
Oecetis		1	1
Platycentropus			*
Plectrocnemia		1	
Pycnopsyche			*
Rhyacophila	1		
TUBIFICIDA			
Enchytraeidae			1

North Dry Sac River 1393_5.2, Greene County			
Date 3/29/2021			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	5	10	
AMPHIPODA			
Crangonyx	2	13	14
Hyaella azteca			2
BASOMMATOPHORA			
Ancylidae	1		
Physella			3
COLEOPTERA			
Dubiraphia		2	2
Macronychus glabratus			1
Neoporus		2	
Psephenus herricki	22	5	
Stenelmis	45	31	8
DECAPODA			
Faxonius luteus	*	2	*
Faxonius virilis			1
DIPTERA			
Ceratopogoninae	2	1	
Chironomidae		1	
Clinocera	22	7	1
Corynoneura	1	1	1
Cricotopus/Orthocladius	9	3	9
Diamesa	1		
Dicrotendipes			1
Eukiefferiella	28	5	6

North Dry Sac River 1393_5.2, Greene County			
Hexatoma	*	*	
Micropsectra	1		1
Nilotanypus	1		
Parakiefferiella		1	
Paratanytarsus			1
Prosimulium	1		
Rheocricotopus	1	1	2
Rheotanytarsus	1		
Simulium	3		2
Stempellinella	1	2	
Sympotthastia	25	11	7
Tabanus	1		
Tanytarsus	1	4	
Thienemannimyia grp	2	12	4
Tipula	5		
Tribelos		1	
Zavrelimyia		1	
EPHEMEROPTERA			
Acentrella	67		8
Acerpenna	1		
Baetis			2
Caenis latipennis	6	55	7
Isonychia bicolor	1		
Leptophlebia		4	
Leucrocuta	11	20	
Paraleptophlebia	1	9	1
Stenacron	16	1	1
Stenonema femoratum	8	5	
Stenonema pulchellum	11	3	
Stenonema terminatum	2		
ISOPODA			
Lirceus		1	
LUMBRICULIDA			
Lumbriculidae	*	1	
MEGALOPTERA			
Corydalus	*		
NEOTAENIOGLOSSA			
Elimia	20	10	185
ODONATA			
Basiaeschna janata			1

North Dry Sac River 1393_5.2, Greene County			
Calopteryx			2
Dromogomphus		*	
Enallagma			1
Gomphidae	1		
Nasiaeschna pentacantha			*
PLECOPTERA			
Acroneuria	1		
Agnetina flavescens	4		
Alloperla	30	72	
Amphinemura	131	3	24
Isoperla	40	*	1
Perlesta	15	18	6
TRICHOPTERA			
Agapetus	1		
Cheumatopsyche	3		
Chimarra	1		
Helicopsyche	13		4
Hydroptila			1
Oecetis		1	3
Polycentropus		1	
Ptilostomis			1
Pycnopsyche	*		2
Rhyacophila	3	2	
Triaenodes	1		3
TRICLADIDA			
Planariidae	5		
TUBIFICIDA			
Tubificinae			
VENEROIDA			
Corbicula		1	

Saline Creek 1048_2.4, Miller County			
Date 3/24/2021			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	12	19	1
AMPHIPODA			
Allocrangonyx		1	
BASOMMATOPHORA			

Saline Creek 1048_2.4, Miller County			
Ancylidae	*		
Physella			*
COLEOPTERA			
Ancyronyx variegatus			2
Dubiraphia			2
Peltodytes			2
Psephenus herricki	1	1	
Stenelmis	3	3	
DECAPODA			
Faxonius luteus		*	2
Faxonius virilis			1
DIPTERA			
Ablabesmyia			2
Ceratopogonidae	5	17	
Chironomus		1	
Cladotanytarsus		6	
Clinocera	36	6	1
Corynoneura		3	4
Cricotopus/Orthocladus	95	13	32
Cryptochironomus		12	1
Dicrotendipes	2	8	8
Empididae (undescribed)	1		
Eukiefferiella	63	1	5
Hemerodromia	4		
Hexatoma	1	1	
Labrundinia			4
Microtendipes	19	14	1
Parametriocnemus	2	1	
Paratanytarsus			19
Phaenopsectra		5	1
Polypedilum flavum	1		
Polypedilum scalaenum grp		3	
Prosimulium	6		
Rheocricotopus	1		1
Rheotanytarsus	5		1
Stempellinella	4	17	
Stictochironomus	2	47	6
Sympotthastia	14	3	6
Tanytarsus	9	14	3
Thienemanniella	2	3	23

Saline Creek 1048_2.4, Miller County			
Thienemannimyia grp	21	11	8
Tipula			*
EPHEMEROPTERA			
Acentrella	5		
Acerpenna	3		7
Caenis latipennis	12	51	144
Isonychia bicolor	2		
Leptophlebia			*
Paraleptophlebia	3	1	7
Stenacron	8	4	3
Stenonema femoratum	9	2	8
Stenonema pulchellum	20		2
Stenonema terminatum	13	1	
Tricorythodes	8		
HEMIPTERA			
Microvelia			1
ISOPODA			
Lirceus			1
LEPIDOPTERA			
Petrophila		*	
MEGALOPTERA			
Corydalus	*		
NEOTAENIOGLOSSA			
Elimia			7
Hydrobiidae		1	
ODONATA			
Argia			1
Basiaeschna janata			*
Boyeria			*
Calopteryx			1
Enallagma			1
Hagenius brevistylus			*
PLECOPTERA			
Acronetia	*		
Amphinemura	26	1	2
Chloroperlidae	2		
Isoperla	5		2
Neoperla	4		
Perlesta	3	1	6
Perlinella drymo			*

Saline Creek 1048_2.4, Miller County			
Perlinella ephyre	3		
Zealeuctra	1		
RHYNCHOBDELLIDA			
Piscicolidae	1		
TRICHOPTERA			
Cheumatopsyche	13		
Chimarra	5		
Helicopsyche		1	
Oecetis			2
Polycentropus	1		
Pycnopsyche			2
Rhyacophila	5		
TRICLADIDA			
Planariidae			2
TUBIFICIDA			
Enchytraeidae		1	
Limnodrilus cervix		2	
Limnodrilus hoffmeisteri		2	
Tubificinae		5	1
VENEROIDA			
Corbicula		2	

Starks Creek 1192_0.6, Hickory County			
Date 3/30/2021			
* - large rare			
ORDER: Observed Taxa	CS	NF	RM
"HYDRACARINA"			
Acarina	8	6	2
AMPHIPODA			
Allocrangonyx		3	
Crangonyx		4	2
Hyaella azteca			15
BRANCHIOBDELLIDA			
Branchiobdellida			1
COLEOPTERA			
Dubiraphia			7
Psephenus herricki	1		*
Stenelmis	8	4	4
DECAPODA			
Faxonius luteus	1	1	2
DIPTERA			

Starks Creek 1192_0.6, Hickory County			
Ablabesmyia		23	1
Ceratopogoninae	22	5	1
Chironomidae	7	7	8
Cladotanytarsus	13	13	1
Clinocera	6	5	
Corynoneura			3
Cricotopus bicinctus			1
Cricotopus/Orthocladius	9	2	9
Cryptochironomus	1	7	
Dicrotendipes	2	5	1
Diptera		3	1
Eukiefferiella	21		6
Hemerodromia	3		3
Hexatoma	18	31	
Hydrobaenus		3	1
Labrundinia			10
Microtendipes	72	32	2
Nilotanytus	1		
Nilothauma		1	
Ormosia		1	
Orthocladius (Euorthocladius)	1		
Parametriocnemus	22	23	2
Paratanytarsus		2	5
Paratendipes		2	
Phaenopsectra	1	1	
Polypedilum aviceps	4		2
Polypedilum flavum	45		3
Polypedilum illinoense grp			1
Polypedilum scalaenum grp		1	
Prosimulium	2		3
Pseudochironomus		4	
Rheocricotopus	1		1
Rheotanytarsus	9		10
Robackia		1	
Simulium	4		9
Stempellinella		1	1
Stenochironomus			2
Stictochironomus	1	20	
Sympotthastia	6	1	6
Tabanus	1		

Starks Creek 1192_0.6, Hickory County			
Tanytarsus	4	10	8
Thienemanniella	1		
Thienemannimyia grp	3	37	15
Tipula	*		
Tribelos		1	
Zavreliomyia		1	2
EPHEMEROPTERA			
Acentrella	2		4
Acerpenna	17	1	7
Caenis latipennis	12	34	61
Eurylophella enoensis			4
Isonychia bicolor	3		
Leptophlebiidae			1
Neocloeon			6
Stenacron	1	4	
Stenonema femoratum	6	3	4
Stenonema mediopunctatum	2		
Stenonema pulchellum	14	1	3
Stenonema terminatum			1
HEMIPTERA			
Microvelia			6
ISOPODA			
Caecidotea (Blind & Unpigmented)		1	
LUMBRICINA			
Lumbricina		1	
MEGALOPTERA			
Corydalus	*		
NEOTAENIOGLOSSA			
Elimia			1
ODONATA			
Argia		1	1
Boyeria			*
Calopteryx			1
Enallagma			6
Macromia		*	
PLECOPTERA			
Alloperla	11	2	
Amphinemura	6		2
Clioperla clio			*

Starks Creek 1192_0.6, Hickory County			
Isoperla	14		
Neoperla	67	57	1
Perlesta	8	3	18
Perlinella ephyre		*	
Prostoia			1
TRICHOPTERA			
Cheumatopsyche	7	3	3
Chimarra	7	*	
Helicopsyche			1
Hydroptila	1		2
Nectopsyche			2
Oecetis	1		7
Plectrocnemia	1		
Ptilostomis			1
Rhyacophila	1	1	1
Triaenodes			2

Appendix C

Multiparameter Data Logger Summary Data; Dissolved Oxygen, Conductivity,
and Temperature: Summer 2020

2020 Data Logger Dissolved Oxygen Summary Report; Lindley Creek and Little Lindley Creek											
* Less than 24 hours of data											
Water Body:		Lindley Creek 1436_19.5, Dallas County				Water Body:		Lindley Creek 1436_20.9, Dallas County			
	Start Date:	08/11/2020					Start Date:	08/11/2020			
	End Date:	08/17/2020					End Date:	08/17/2020			
DO Summary						DO Summary					
Mean (mg/l):		7.07	% below 5.0 mg/L:		26.9%	Mean (mg/l):		5.49	% below 5.0 mg/L:		51.0%
Mean Min (mg/l):		4.69	Number <5.0 mg/L:		154	Mean Min (mg/l):		3.39	Number <5.0 mg/L:		292
Mean Max (mg/l):		10.49	Total measurements:		572	Mean Max (mg/l):		9.14	Total measurements:		573
Daily summary:						Daily summary:					
Day	Date	Mean mg/l	Minimum mg/l	Maximum mg/l	Δ mg/l	Day	Date	Mean mg/l	Minimum mg/l	Maximum mg/l	Δ mg/l
*1	08/11/2020	8.74	5.70	10.84	5.14	*1	08/11/2020	7.94	5.63	9.73	4.10
2	08/12/2020	7.19	5.00	10.55	5.55	2	08/12/2020	6.11	4.21	9.57	5.36
3	08/13/2020	7.24	4.40	10.96	6.56	3	08/13/2020	5.45	3.28	9.44	6.16
4	08/14/2020	6.90	4.27	10.58	6.31	4	08/14/2020	5.14	3.13	8.96	5.83
5	08/15/2020	7.00	4.32	11.37	7.05	5	08/15/2020	5.67	2.85	10.75	7.90
6	08/16/2020	7.24	4.51	11.57	7.06	6	08/16/2020	5.32	2.39	10.95	8.56
*7	08/17/2020	5.16	4.62	7.53	2.91	*7	08/17/2020	2.79	2.26	4.60	2.34
Water Body:		Little Lindley Creek 1438_2.5, Dallas County				Water Body:		Little Lindley Creek 1438_3.6, Dallas County			
	Start Date:	08/11/2020					Start Date:	08/11/2020			
	End Date:	08/17/2020					End Date:	08/17/2020			
DO Summary						DO Summary					
Mean (mg/l):		8.01	% below 5.0 mg/L:		0.0%	Mean (mg/l):		6.05	% below 5.0 mg/L:		19.4%
Mean Min (mg/l):		6.78	Number < 5.0 mg/L:		0	Mean Min (mg/l):		4.83	Number <5.0 mg/L:		112
Mean Max (mg/l):		10.28	Total measurements:		574	Mean Max (mg/l):		7.75	Total measurements:		576
Daily summary:						Daily summary:					
Day	Date	Mean mg/l	Minimum mg/l	Maximum mg/l	Δ mg/l	Day	Date	Mean mg/l	Minimum mg/l	Maximum mg/l	Δ mg/l
*1	08/11/2020	8.68	7.08	10.16	3.08	*1	08/11/2020	7.00	5.41	8.19	2.78
2	08/12/2020	7.85	6.64	9.98	3.34	2	08/12/2020	6.08	4.95	7.81	2.86
3	08/13/2020	7.99	6.60	10.67	4.07	3	08/13/2020	6.09	4.77	8.07	3.30
4	08/14/2020	7.84	6.59	10.45	3.86	4	08/14/2020	5.95	4.66	8.00	3.34
5	08/15/2020	8.00	6.60	10.83	4.23	5	08/15/2020	5.96	4.53	8.07	3.54
6	08/16/2020	8.28	6.83	10.94	4.11	6	08/16/2020	6.17	4.72	8.46	3.74
*7	08/17/2020	7.44	7.12	8.93	1.81	*7	08/17/2020	5.13	4.80	5.65	0.85

2020 Data Logger Conductivity Summary Report; Lindley Creek and Little Lindley Creek												
* Less than 24 hours of data												
Water Body:		Lindley Creek 1436 -19.5, Dallas County					Water Body:		Lindley Creek 1436_20.9, Dallas County			
Start Date:		08/11/2020				Start Date:		08/11/2020				
End Date:		08/17/2020				End Date:		08/17/2020				
Specific Conductance Summary						Specific Conductance Summary						
Mean Min (µS/cm):		439.29		Mean (µS/cm):		453.15		Mean Min (µS/cm):		421.86		
Mean Max (µS/cm):		464.43		Total measurements:		572		Mean Max (µS/cm):		432.71		
								Total measurements:		573		
Daily summary:						Daily summary:						
Day	Date	Mean µS/cm	Minimum µS/cm	Maximum µS/cm	Δ µS/cm	Day	Date	Mean µS/cm	Minimum µS/cm	Maximum µS/cm	Δ µS/cm	
*1	08/11/2020	443.60	437.00	459.00	22.00	*1	08/11/2020	420.41	416.00	425.00	9.00	
2	08/12/2020	460.69	453.00	466.00	13.00	2	08/12/2020	424.51	413.00	428.00	15.00	
3	08/13/2020	459.82	452.00	465.00	13.00	3	08/13/2020	427.31	424.00	431.00	7.00	
4	08/14/2020	459.30	447.00	467.00	20.00	4	08/14/2020	428.67	425.00	433.00	8.00	
5	08/15/2020	460.17	452.00	468.00	16.00	5	08/15/2020	429.25	423.00	434.00	11.00	
6	08/16/2020	427.29	375.00	463.00	88.00	6	08/16/2020	431.67	424.00	441.00	17.00	
*7	08/17/2020	461.21	459.00	463.00	4.00	*7	08/17/2020	433.59	428.00	437.00	9.00	
Water Body:		Little Lindley Creek 1438 2.5, Dallas County				Water Body:		Little Lindley Creek 1438_3.6, Dallas County				
Start Date:		08/11/2020				Start Date:		08/11/2020				
End Date:		08/17/2020				End Date:		08/17/2020				
Specific Conductance Summary						Specific Conductance Summary						
Mean Min (µS/cm):		559.14		Mean (µS/cm):		565.03		Mean Min (µS/cm):		587.14		
Mean Max (µS/cm):		573.57		Total measurements:		574		Mean Max (µS/cm):		611.86		
								Total measurements:		576		
Daily summary:						Daily summary:						
Day	Date	Mean µS/cm	Minimum µS/cm	Maximum µS/cm	Δ µS/cm	Day	Date	Mean µS/cm	Minimum µS/cm	Maximum µS/cm	Δ µS/cm	
*1	08/11/2020	562.08	556.00	566.00	10.00	*1	08/11/2020	532.06	525.00	552.00	27.00	
2	08/12/2020	539.92	529.00	560.00	31.00	2	08/12/2020	570.23	554.00	580.00	26.00	
3	08/13/2020	544.05	535.00	556.00	21.00	3	08/13/2020	585.21	574.00	597.00	23.00	
4	08/14/2020	562.12	556.00	569.00	13.00	4	08/14/2020	598.71	586.00	612.00	26.00	
5	08/15/2020	573.09	569.00	580.00	11.00	5	08/15/2020	616.52	604.00	632.00	28.00	
6	08/16/2020	583.33	579.00	592.00	13.00	6	08/16/2020	636.15	622.00	655.00	33.00	
*7	08/17/2020	590.64	590.00	592.00	2.00	*7	08/17/2020	651.02	645.00	655.00	10.00	

2020 Data Logger Temperature Summary Report; Lindley Creek and Little Lindley Creek												
* Less than 24 hours of data												
Water Body:		Lindley Creek 1436 -19.5, Dallas County					Water Body:		Lindley Creek 1436_20.9, Dallas County			
	Start Date:	08/11/2020						Start Date:	08/11/2020			
	End Date:	08/17/2020						End Date:	08/17/2020			
Temperature Summary							Temperature Summary					
Mean Min (°C):		23.57		Mean (°C): 25.34			Mean Min (°C):		23.11		Mean (°C): 24.80	
Mean Max (°C):		26.99		Total measurements: 572			Mean Max (°C):		26.73		Total measurements: 573	
Daily summary:							Daily summary:					
Day	Date	Mean °C	Minimum °C	Maximum °C	Δ °C		Day	Date	Mean °C	Minimum °C	Maximum °C	Δ °C
*1	08/11/2020	26.31	25.29	27.09	1.80		*1	08/11/2020	25.49	24.08	26.19	2.11
2	08/12/2020	25.90	23.57	28.22	4.65		2	08/12/2020	25.34	23.25	27.71	4.46
3	08/13/2020	26.18	24.05	28.20	4.15		3	08/13/2020	25.64	23.76	27.77	4.01
4	08/14/2020	26.32	24.19	28.13	3.94		4	08/14/2020	25.72	23.92	27.92	4.00
5	08/15/2020	25.80	24.05	27.37	3.32		5	08/15/2020	25.43	23.65	27.83	4.18
6	08/16/2020	24.41	22.13	25.98	3.85		6	08/16/2020	24.06	22.06	26.26	4.20
*7	08/17/2020	22.47	21.71	23.91	2.20		*7	08/17/2020	21.93	21.08	23.40	2.32
Water Body:		Little Lindley Creek 1438 2.5, Dallas County					Water Body:		Little Lindley Creek 1438_3.6, Dallas County			
	Start Date:	08/11/2020						Start Date:	08/11/2020			
	End Date:	08/17/2020						End Date:	08/17/2020			
Temperature Summary							Temperature Summary					
Mean Min (°C):		22.46		Mean (°C): 24.09			Mean Min (°C):		21.99		Mean (°C): 23.04	
Mean Max (°C):		25.01		Total measurements: 574			Mean Max (°C):		24.16		Total measurements: 576	
Daily summary:							Daily summary:					
Day	Date	Mean °C	Minimum °C	Maximum °C	Δ °C		Day	Date	Mean °C	Minimum °C	Maximum °C	Δ °C
*1	08/11/2020	24.08	23.22	24.69	1.47		*1	08/11/2020	23.49	22.65	24.05	1.40
2	08/12/2020	24.08	22.55	25.70	3.15		2	08/12/2020	23.39	22.18	24.79	2.61
3	08/13/2020	24.39	22.90	25.94	3.04		3	08/13/2020	23.52	22.41	24.78	2.37
4	08/14/2020	24.62	23.28	26.13	2.85		4	08/14/2020	23.83	22.64	25.22	2.58
5	08/15/2020	24.35	23.05	26.20	3.15		5	08/15/2020	23.62	22.53	24.92	2.39
6	08/16/2020	23.00	21.49	24.56	3.07		6	08/16/2020	22.42	21.15	23.46	2.31
*7	08/17/2020	21.19	20.75	21.82	1.07		*7	08/17/2020	20.99	20.39	21.92	1.53

2020 Data Logger Dissolved Oxygen Summary Report; CANDREF Stations												
* Less than 24 hours of data												
Water Body:		Brush Creek 1370_2.9, St. Clair County					Water Body:		Macks Creek 1200_2.4, Camden County			
	Start Date:		09/03/2020				Start Date:		09/03/2020			
	End Date:		09/10/2020				End Date:		09/10/2020			
DO Summary						DO Summary						
Mean (mg/l):		7.77	% below 5.0 mg/L:		0.0%	Mean (mg/l):		6.46	% below 5.0 mg/L:		7.2%	
Mean Min (mg/l):		6.29	Number < 5.0 mg/L:		0	Mean Min (mg/l):		5.35	Number < 5.0 mg/L:		48	
Mean Max (mg/l):		10.29	Total measurements:		672	Mean Max (mg/l):		8.20	Total measurements:		671	
Daily summary:						Daily summary:						
Day	Date	Mean mg/l	Minimum mg/l	Maximum mg/l	Δ mg/l	Day	Date	Mean mg/l	Minimum mg/l	Maximum mg/l	Δ mg/l	
*1	09/03/2020	7.75	6.60	8.85	2.25	*1	09/03/2020	7.07	5.48	8.49	3.01	
2	09/04/2020	7.74	6.38	10.34	3.96	2	09/04/2020	6.71	5.37	9.01	3.64	
3	09/05/2020	8.11	6.66	10.77	4.11	3	09/05/2020	6.55	5.44	8.64	3.20	
4	09/06/2020	8.10	6.35	11.41	5.06	4	09/06/2020	6.34	5.16	8.39	3.23	
6	09/07/2020	7.89	6.00	11.39	5.39	5	09/07/2020	6.07	4.87	8.08	3.21	
5	09/08/2020	7.69	5.72	11.06	5.34	6	09/08/2020	6.15	4.78	8.19	3.41	
7	09/09/2020	7.97	6.05	10.73	4.68	7	09/09/2020	6.81	5.96	7.89	1.93	
*8	09/10/2020	6.93	6.54	7.80	1.26	*8	09/10/2020	5.98	5.75	6.90	1.15	
Water Body:		Saline Creek 1048_2.4, Miller County					Water Body:		Starks Creek 1192_0.6, Hickory County			
	Start Date:		09/03/2020				Start Date:		09/03/2020			
	End Date:		09/10/2020				End Date:		09/10/2020			
DO Summary						DO Summary						
Mean (mg/l):		5.95	% below 5.0 mg/L:		24.5%	Mean (mg/l):		6.40	% below 5.0 mg/L:		0.0%	
Mean Min (mg/l):		4.95	Number < 5.0 mg/L:		164	Mean Min (mg/l):		5.67	Number < 5.0 mg/L:		0	
Mean Max (mg/l):		7.46	Total measurements:		670	Mean Max (mg/l):		7.50	Total measurements:		672	
Daily summary:						Daily summary:						
Day	Date	Mean mg/l	Minimum mg/l	Maximum mg/l	Δ mg/l	Day	Date	Mean mg/l	Minimum mg/l	Maximum mg/l	Δ mg/l	
*1	09/03/2020	6.29	5.26	7.75	2.49	*1	09/03/2020	7.25	6.11	7.98	1.87	
2	09/04/2020	6.21	5.23	8.06	2.83	2	09/04/2020	6.83	5.95	8.21	2.26	
3	09/05/2020	5.85	4.66	7.58	2.92	3	09/05/2020	6.71	6.00	7.92	1.92	
4	09/06/2020	5.37	4.15	7.23	3.08	4	09/06/2020	6.41	5.67	7.68	2.01	
5	09/07/2020	4.99	3.77	6.86	3.09	5	09/07/2020	6.07	5.32	7.19	1.87	
6	09/08/2020	5.28	3.64	7.19	3.55	6	09/08/2020	5.93	5.32	6.90	1.58	
7	09/09/2020	7.00	6.43	7.82	1.39	7	09/09/2020	6.19	5.43	7.39	1.96	
*8	09/10/2020	6.61	6.43	7.16	0.73	*8	09/10/2020	5.78	5.55	6.72	1.17	

2020 Data Logger Conductivity Summary Report; CANDREF Stations												
* Less than 24 hours of data												
Water Body:		Brush Creek 1370_2.9 St. Clair County					Water Body:		Macks Creek 1200_2.4, Camden County			
	Start Date:	09/03/2020						Start Date:	09/03/2020			
	End Date:	09/10/2020						End Date:	09/10/2020			
Specific Conductance Summary							Specific Conductance Summary					
Mean Min (µS/cm):		336.75		Mean (µS/cm):		345.31		Mean Min (µS/cm):		363.75		
Mean Max (µS/cm):		353.13		Total measurements:		672		Mean Max (µS/cm):		455.88		
Daily summary:							Daily summary:					
Day	Date	Mean µS/cm	Minimum µS/cm	Maximum µS/cm	Δ µS/cm		Day	Date	Mean µS/cm	Minimum µS/cm	Maximum µS/cm	
*1	09/03/2020	283.15	273.00	294.00	21.00		*1	09/03/2020	475.35	473.00	477.00	
2	09/04/2020	306.70	294.00	320.00	26.00		2	09/04/2020	476.06	473.00	478.00	
3	09/05/2020	329.39	320.00	339.00	19.00		3	09/05/2020	475.66	471.00	478.00	
4	09/06/2020	345.51	339.00	354.00	15.00		4	09/06/2020	478.03	476.00	479.00	
5	09/07/2020	359.29	355.00	368.00	13.00		5	09/07/2020	479.77	478.00	481.00	
6	09/08/2020	370.58	366.00	374.00	8.00		6	09/08/2020	448.65	79.00	482.00	
7	09/09/2020	379.16	363.00	384.00	21.00		7	09/09/2020	299.63	109.00	350.00	
*8	09/10/2020	388.68	384.00	392.00	8.00		*8	09/10/2020	358.87	351.00	422.00	
Water Body:		Saline Creek 1048_2.4, Miller County					Water Body:		Starks Creek 1192_0.6, Hickory County			
	Start Date:	09/03/2020						Start Date:	09/03/2020			
	End Date:	09/10/2020						End Date:	09/10/2020			
Specific Conductance Summary							Specific Conductance Summary					
Mean Min (µS/cm):		308.75		Mean (µS/cm):		402.72		Mean Min (µS/cm):		417.50		
Mean Max (µS/cm):		426.13		Total measurements:		670		Mean Max (µS/cm):		421.88		
Daily summary:							Daily summary:					
Day	Date	Mean µS/cm	Minimum µS/cm	Maximum µS/cm	Δ µS/cm		Day	Date	Mean µS/cm	Minimum µS/cm	Maximum µS/cm	
*1	09/03/2020	427.63	2.00	436.00	434.00		*1	09/03/2020	421.22	420.00	422.00	
2	09/04/2020	438.63	435.00	442.00	7.00		2	09/04/2020	421.10	420.00	422.00	
3	09/05/2020	443.93	441.00	447.00	6.00		3	09/05/2020	419.62	417.00	421.00	
4	09/06/2020	448.90	445.00	455.00	10.00		4	09/06/2020	421.14	420.00	423.00	
5	09/07/2020	454.87	451.00	466.00	15.00		5	09/07/2020	423.23	422.00	424.00	
6	09/08/2020	398.65	204.00	461.00	257.00		6	09/08/2020	419.41	408.00	424.00	
7	09/09/2020	265.66	162.00	330.00	168.00		7	09/09/2020	417.29	415.00	418.00	
*8	09/10/2020	343.54	330.00	372.00	42.00		*8	09/10/2020	419.02	418.00	421.00	

2020 Data Logger Temperature Summary Report; CANDREF Stations											
* Less than 24 hours of data											
Water Body:		Brush Creek 1370_2.9 St. Clair County				Water Body:		Macks Creek 1200_2.4, Camden County			
	Start Date:		09/03/2020				Start Date:		09/03/2020		
	End Date:		09/10/2020				End Date:		09/10/2020		
Temperature Summary						Temperature Summary					
Mean Min (°C):		22.98		Mean (°C): 24.49		Mean Min (°C):		22.13		Mean (°C): 23.48	
Mean Max (°C):		26.14		Total measurements: 672		Mean Max (°C):		22.01		Total measurements: 671	
Daily summary:						Daily summary:					
		Mean °C	Minimum °C	Maximum °C	Δ °C			Mean °C	Minimum °C	Maximum °C	Δ °C
Day	Date	°C	°C	°C	°C	Day	Date	°C	°C	°C	°C
*1	09/03/2020	25.02	22.72	25.94	3.22	*1	09/03/2020	24.62	23.55	25.41	1.86
2	09/04/2020	24.12	22.53	25.51	2.98	2	09/04/2020	23.29	22.08	24.71	2.63
3	09/05/2020	24.15	22.39	26.19	3.80	3	09/05/2020	23.30	21.90	25.26	3.36
4	09/06/2020	25.50	23.54	27.91	4.37	4	09/06/2020	24.00	22.66	25.73	3.07
5	09/07/2020	26.26	24.39	28.60	4.21	5	09/07/2020	24.47	23.20	26.33	3.13
6	09/08/2020	25.91	24.69	27.86	3.17	6	09/08/2020	23.78	20.72	25.10	4.38
7	09/09/2020	23.21	22.30	24.62	2.32	7	09/09/2020	22.07	20.87	23.55	2.68
*8	09/10/2020	21.78	21.24	22.47	1.23	*8	09/10/2020	22.26	22.05	22.99	0.94
Water Body:		Saline Creek 1048_2.4, Miller County				Water Body:		Starks Creek 1192_0.6, Hickory County			
	Start Date:		09/03/2020				Start Date:		09/03/2020		
	End Date:		09/10/2020				End Date:		09/10/2020		
Temperature Summary						Temperature Summary					
Mean Min (°C):		21.51		Mean (°C): 22.75		Mean Min (°C):		22.75		Mean (°C): 23.82	
Mean Max (°C):		24.63		Total measurements: 670		Mean Max (°C):		24.87		Total measurements: 672	
Daily summary:						Daily summary:					
		Mean °C	Minimum °C	Maximum °C	Δ °C			Mean °C	Minimum °C	Maximum °C	Δ °C
Day	Date	°C	°C	°C	°C	Day	Date	°C	°C	°C	°C
*1	09/03/2020	24.16	23.21	26.14	2.93	*1	09/03/2020	24.89	23.33	25.52	2.19
2	09/04/2020	22.44	21.06	24.22	3.16	2	09/04/2020	23.60	22.43	24.61	2.18
3	09/05/2020	22.28	20.66	24.78	4.12	3	09/05/2020	23.30	21.89	24.96	3.07
4	09/06/2020	23.28	21.78	25.35	3.57	4	09/06/2020	24.12	22.64	25.69	3.05
5	09/07/2020	23.75	22.41	25.98	3.57	5	09/07/2020	24.77	23.44	26.29	2.85
6	09/08/2020	22.85	21.31	24.26	2.95	6	09/08/2020	24.20	23.52	24.98	1.46
7	09/09/2020	21.64	20.42	23.27	2.85	7	09/09/2020	23.17	22.49	23.93	1.44
*8	09/10/2020	21.63	21.21	23.02	1.81	*8	09/10/2020	22.48	22.22	22.94	0.72